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## Forthcoming Events.

DECEMBER 19.

*Institution of Production Engineers*:—General meeting in London. "Electric Furnaces," Paper by L. W. Wild.

*North-East Coast of Engineers and Shipbuilders*:—Ordinary meeting at Newcastle-on-Tyne. "Internal Combustion Engines," Paper by F. C. Leigh.

DECEMBER 20.

*Institution of British Foundrymen (Falkirk and District Branch)*:—Open meeting for the discussion of foundry problems.

*Institution of Locomotive Engineers*:—General meeting in London. "Notes on Locomotive Running Trials," Paper by E. A. Phillipson.

**THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTE OF BRITISH FOUNDRYMEN AND THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION.**

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**Secretary: E. J. Griffiths, 20, Fisher Street, Swansea.**

## The Decline of Semi-Steel.

For some weeks now our readers have been carrying on a correspondence as to whether semi-steel is on the decline and is being replaced by special iron. Professor Campion hints that suppliers have no right to designate high-manganese iron as "special," and it seems desirable, therefore, to define the nature of materials which can be justly placed into this category. We submit, therefore, that they consist of irons not falling into the ordinary trade classification, and that the deviation from the classification is ordered and controlled within set limits or that its manufacture has been conducted in a furnace other than hot-blast and metallurgically superior.

Mr. F. W. Rowe's Paper on "The Selection of Pig-iron for High-Grade Castings," printed elsewhere in this issue, comes at a very opportune time, as it is a dissertation on the very subject under discussion. The one point which it seems to emphasise, to our mind, is the limited assimilating power of the cupola. He places the maximum amount of steel which can be assimilated in one melt by the cupola as 20 per cent. It is not generally known, but was hinted at in Mr. H. J. Young's contribution to the discussion on Mr. F. J. Cook's Paper recently given to the Newcastle Branch of the Institute of British Foundrymen dealing with some aspects of cupola practice, that there is a limit to the amount of sulphur which can be assimilated during one melt in the cupola.

This may be considered as being somewhat removed from the subject, but it has a very distinct bearing. Any decline in the use of semi-steel can probably be traced to the unsuitability of many cupola installations for its manufacture. Years of experience have led designers to produce an apparatus very suitable for melting pig-iron and scrap mixtures, and not for making semi-steel. For the successful melting of semi-steel some modifications are desirable, and many foundries have carried out alterations and find no necessity for abandoning its manufacture, but are daily improving its quality.

Another factor is the quantity required. The problem of the production of semi-steel is greatly simplified if a long run can be put through daily, whereas if only a small percentage of the daily output is to be semi-steel, then the difficulty of separating charges in the cupola is introduced.

On the other side, there seems to be some support for the factor that special irons are now of more regular and better quality than has been the case for some years, and that really serious attempts are being made to sell material of definite chemical composition, and this, to pacify the group with which Mr. Rowe has identified himself, associated with a corresponding fracture.

To deviate a moment from the subject, and dealing with one closely allied, we would draw the attention of foundrymen again to the limited assimilating power of the average cupola. It has repeatedly been stated that the characteristics of irons are retained when passing through the cupola. This can be ascribed to the limited assimilating power of the crucible. It has been laid down that hematite will not mix satisfactorily with a high phosphorus iron when cupola melted. We have no hesitation in putting forward our belief that this does not apply to electric-melting. Electric-melting has broken down somewhat the faith in the "body" of Swedish bar iron and can be expected to do the same for the cast iron industry—but at a price.

XUM

## Correspondence.

*[We accept no responsibility for the statements made or the opinions expressed by our correspondents.]*

### Briquetting of C.I. Borings.

*To the Editor of* THE FOUNDRY TRADE JOURNAL.

SIR,—I have read with interest the Paper on the use of cast-iron borings written by my friend, Mr. Gardner, of Kilmarnock, and published in your issue of December 13.

The method of briquetting described by Mr. Gardner appears to be very satisfactory. The iron produced, however, is not of a nature which will commend it for all-round work. The sulphur content is high both in the direct melt of the briquettes, and after dilution, with high-silicon pig and scrap. In the latter case 0.15 per cent. sulphur was found in an iron with 2.3 per cent. silicon. This may be no disadvantage for fairly simple castings, and will probably meet most physical specifications. Such a high sulphur is not generally desirable for intricate work and for designs which are liable to shrinkage troubles. Certainly I would not value it at £6 per ton as Mr. Gardner has done.

Coming now to costs, Mr. Gardner's balance sheet shows a good margin in favour of the briquetting process. This is based on the valuation of cast iron borings at 30s. per ton. In the same issue of the FOUNDRY TRADE JOURNAL the Cleveland price of borings is given at 70s. The price obtained in Glasgow to-day is 69s., with no deduction for cartage. The cost of briquetting works out at 9s. 6d. per ton, hence the cost of the briquettes ready for melting in this district would be 78s. 6d. per ton. The briquettes could scarcely be said to be of any better quality than ordinary cast-iron scrap, which is worth 85s. to 92s., hence the saving due to the use of borings is somewhere about 10s. per ton. One can understand that the method would probably be a paying proposition to a foundry situated in some part of the country where there is difficulty in disposing of borings, or where the freight to the nearest steel works is heavy.

It is mentioned in the "Editorial" of the same issue of your paper that a large engineering works in England is reported to be actually paying for the removal of cast-iron borings. Surely there must be some special difficulties connected with the location of this works, else, why should a material which is dense and easily handled and which is worth £3 10s. in certain parts of the country have a minus value?—Yours, etc.,

JOHN ARNOTT.

Laboratory of G. & J. Weir, Limited,
Cathcart, Glasgow.
December 15, 1923.

## B.C.I.R.A. Appoint Director.

Mr. J. G. Pearce, a member of the laboratory staff of Metropolitan-Vickers Electrical Company, Limited, Manchester, has been appointed by the Council of the British Cast Iron Research Association as Director of Research in succession to Dr. Percy Longmuir, who lately resigned. Mr. Pearce is 33 years of age, and is a member of the Institute of Metals, as well as of the Institution of Electrical Engineers, and has rendered good service on the Council of the Non-Ferrous Research Association. He was trained at Birmingham University, and for many years has been on the Metropolitan-Vickers staff making a special study of non-ferrous metals and electrical work. The Manchester firm has a large foundry, and Mr. Pearce will therefore be generally familiar with foundry work. Following his study at the Birmingham University, where he was an engineering student, he obtained his degree of Bachelor of Science, taking the full course of metallurgy. He is the author of a book on "Works Training," and joint author with Mr. Fleming of a work dealing with the organisation of research and entitled "Research in Industry."

## Crewe Students Visit Stanton Ironworks.

Last Saturday the students of the foundry and moulding classes held at the Crewe Technical Institute paid a visit to the works of the Stanton Ironworks Company, where they were shown the manufacture of cast-iron pipes by the centrifugal process. One 15-inch socketted pipe, 12 ft. long, is made by four men and one machine in about two minutes. They also inspected the manufacture of concrete-lined cast-iron pipes, as well as plain and reinforced concrete pipes of a diameter such as is used for sewage and other purposes.

After the inspection, the party were entertained to lunch by Mr. E. J. Fox, the managing director, who addressed the Crewe students as men seeking to advance their knowledge in their own particular branch of work, and said that if employers of to-day would continue to see the mutual advantage of offering every encouragement and facility to employees who were sufficiently enterprising to go out of their way to seek knowledge true progress would be made.

On behalf of the Crewe Education Committee and the Principal of the Crewe Technical Institute, Mr. J. Hughes, teacher of the foundry and moulding classes, thanked the directorate of the Stanton Company, and also complimented the company on having succeeded where many had failed in developing a process to a point of the revolution of existing orthodox methods. He considered that it was an encouraging sign of real progress when directors of big industries laid themselves out to receive and to instruct parties of genuine students in such a way.

Mr. L. J. Button, of the Borough Foundry, Crewe, seconded the vote of thanks.

## Death of Well-known Foundry Owner.

WE REGRET TO ANNOUNCE the death, last Thursday, at Bournemouth, of Mr. William T. Stubbs, the chairman of directors of Messrs. Joseph Stubbs, Limited, of Ancoats and Openshaw, Manchester. Mr. Stubbs, though not so well known as his brother, Mr. Oliver Stubbs, in technical circles, was a very prominent figure amongst the Lancashire commercial community, especially those attached to the textile industries. Though Mr. W. T. Stubbs was an invalid for many years, his death was quite unexpected.

## Book Review.

**Mechanical World Year Book, 1924.** Published by Messrs. Emmott & Company, Limited, 20, Bedford Street, London, W.C.2. Price 1s. 6d.

The additions this year are of distinct interest for our readers, as they include a section dealing with combustion. The greatest value of books of this nature lies in the index. Many reference books contain the item of information sought, but defective indexing may make it impossible of being found, and in this particular case we suggest improvements could be effected.

## Production of Iron and Steel in November.

The production of pig-iron in November amounted to 597,600 tons compared with 595,700 tons in October and 493,900 tons in November, 1922. The furnaces in blast at the end of the month numbered 199, an increase of 10 during the month. The total includes 184,100 tons of hematite, 204,000 tons of basic, 152,400 tons of foundry and 26,100 tons of forge pig-iron. The output of steel ingots and castings amounted to 749,500 tons compared with 702,200 tons in October and 600,800 tons in November, 1922

SMEETON-WRIGHT FURNACES, LIMITED, have recently obtained an order from W. Shanks & Company, Limited, Tubal Works, Barrhead, near Glasgow, for a large bath enamelling muffle furnace of the self-contained continuous recuperative type.

# The Selection of Pig-irons for High-grade Cast-iron.*

By F. W. Rowe, M.I.Brit. F.

There is hardly another phase of iron founding concerning which there is more divergence of opinion, or more lack of understanding of the basic principles involved, than the proper selection of the components for the production of high-grade cast iron. It is seldom one meets two iron foundries using the same irons, or whose ideas do not radically differ. Lest it should be misunderstood, it is well to emphasise at the outset that the selection of pig-irons, though a vital factor in high-class iron founding, is hardly more important than correct melting and casting conditions. There has been a great tendency in the past on the part of metallurgists and chemists to assess the value of a pig-iron solely on the analysis shown, without any regard to the raw materials from which the pig has been made or the conditions of smelting or the fracture exhibited. Unfortunately the opinion that the only criterion of a pig-iron is its analysis has recently been reiterated by people who should know better. It is to be deplored as a retrograde step, and one which will not be supported by those who have approached the subject from an unprejudiced standpoint.

It rather looks that, with those who hold this opinion, "the wish is father to the thought," and certainly iron founding would be a great deal simpler if it were so. Most people will agree, however, that analyses, though important, do not tell the whole story, and due consideration must be paid to other characteristics of a pig-iron.

The selection of raw materials for the commoner classes of castings is, of course, chiefly governed by economic considerations, the actual strength of the iron being of minor importance, and the skill of the foundrymen is more profitably expended in ensuring that clean, sound castings are produced.

When, however, one turns to the highest class of engineering castings, such as steam and internal-combustion engine parts and hydraulic work, the initial cost of the raw materials is a matter of secondary importance, provided the resulting castings successfully withstand the duties imposed upon them in service. Indeed, it is a bad business policy to be parsimonious in the matter of pig-irons for high-class work, and no lasting reputation has ever been built up where such a policy has existed. As regards the analytical requirements for high-grade cast iron, these can be defined within fairly narrow limits for all normal work.

Table I sets out on a broad basis the proportions of the various elements desirable. It will

TABLE I.—*Analysis of Cast-iron for High-grade Work.*

| | Percentages. |
|---|---|
| Total Carbon .. .. .. | 3.0 to 3.3 |
| Combined Carbon .. .. | 0.6 to 1.0 |
| Graphitic Carbon .. .. .. | 2.3 to 2.7 |
| Silicon .. .. .. .. | 1.0 to 1.8 |
| Sulphur .. .. .. .. | 0.10 to 0.15 |
| Phosphorus .. .. .. | 0.3 to 0.8 |
| Manganese .. .. .. .. | 0.5 to 0.7 |

perhaps suit the purposes of this Paper better if the elements are dealt with in order of ascending importance.

### Manganese.

The chief value of manganese in cast iron is to counteract the evil effect of sulphur, and as long as sufficient is present to do this, *i.e.*, above 0.40 per cent. for a normal iron, one need not worry further about the manganese content. It has been asserted that manganese tends to whiten cast iron, but this is unsupported by experience and research work, and it can be safely said that in those proportions met with in cast iron, *i.e.*, 0.40 to 1.5 per cent., it is without effect on the iron carbide-graphite ratio.

* Paper presented before the East Midlands Branch of the Institute of British Foundrymen.

### Sulphur.

This element, which has been named the "bogey" of the iron foundry, should not trouble the iron founder whose supplies are normal. It should be kept within the limits given. This is an easy matter provided a good coke with a maximum sulphur content of 1.0 per cent. and a slag with not less than 35 per cent. lime is used. Up to 0.1 per cent. sulphur has a distinctly beneficial effect on cast iron, as it tends to give a finer graphite. Experience has shown that it is extremely hard to get iron of high strength with abnormally low sulphur content. Above 0.15 per cent. sulphur tends to become a menace, depending on the class of work for which the iron is used. The iron has distinctly less life and is more liable to blow and shrinkage defects are accentuated. These faults are, of course, more pronounced in light than in heavy sections.

### Phosphorus.

The limits for phosphorus have been set down fairly widely owing to the variation in the requirements for different classes of work. There is no

TABLE II.—*Impact Tests using a 120 ft.-lb. Izod Machine. Bars 20 mm. × 20 mm. × 75 mm. with no Notch.*

| Analysis. | No. 1. | No. 2. | No. 3. | No. 4. |
|---|---|---|---|---|
| Total Carbon .. .. | 3.31 | 3.21 | 3.17 | 3.28 |
| Graphite Carbon .. .. | 2.69 | 2.64 | 2.44 | 2.58 |
| Combined Carbon .. .. | 0.62 | 0.57 | 0.73 | 0.70 |
| Silicon .. .. .. | 1.46 | 1.68 | 1.31 | 1.18 |
| Sulphur .. .. .. | 0.096 | 0.107 | 0.092 | 0.101 |
| Phosphorus .. .. .. | 0.36 | 0.68 | 0.88 | 1.29 |
| Manganese .. .. .. | 0.46 | 0.62 | 0.53 | 0.58 |
| Energy absorbed in ft.-lbs. | 29.00 | 22.60 | 16.00 | 10.50 |

conclusive evidence that phosphorus up to 1.0 per cent. seriously diminishes the tensile or transverse strength of cast iron. The resistance of cast iron to fracture by shock is greatly influenced by the phosphorus content. High-phosphorus cast irons (0.8 to 1 per cent.) are definitely weaker against show than low phosphorus (0.2 to 0.3). Anyone who possesses an Izod impact-testing machine can easily verify this fact.

Table II shows the results of some impact tests on irons only varying to an appreciable extent in phosphorus content. These figures have been selected on account of the uniformity of the analyses and well illustrate the conclusions which have been drawn from the study of some hundreds of similar tests. Phosphorus also is distinctly harmful to castings which have to undergo changes in temperature. For internal-combustion and steam-engine cylinders, valves, etc., the phosphorus should be kept as low as is consistent with safe working in the foundry. High-phosphorus castings are much more liable to crack under repeated temperature changes than those in which this element is low. High phosphorus should not be allowed in work subjected to steam pressure as the phosphide is rapidly attacked in such situations. In heavy work and in castings having rapid changes of section, the phosphorus should not be above 0.3 to 0.5 per cent., or considerable difficulty will be experienced due to porosity caused by liquation of the eutectic.

### Combined Carbon.

The percentage of combined carbon is, of course, governed by the silicon content and the rate of cooling. The combined carbon to obtain the best strength and hardness and best resistance to wear should be kept as high as possible consistent with normal machining practice. It is usually a safe guide to arrange that the thinnest section of the casting shall have a combined carbon content of not more than 0.75 per cent., and preferably, of course, not less. No difficulty should ever be experienced in machining a cast iron with this

combined carbon content, though, of course, the feeds and speeds will not be as high as the machine-shop superintendent would like.

### Silicon.

The silicon content varies within the limits given and, according to the thickness of metal, to give the required combined carbon content.

### Graphite Carbon.

The graphite carbon is by far the most important constituent of a cast iron, and is worthy of a great deal more time than can possibly be devoted to it here. The amount, form and distribution of graphite has by far the greatest influence on the strength of cast iron. This fact is often not as fully appreciated as it might be. Undue importance is usually attached to the amount of other elements present. It is doubtful whether the combined carbon *per se* has any effect on the actual strength of cast iron, although it is essential for wearing properties. It is more likely that the beneficial effect of the combined carbon is an indirect one. By that is meant the effect on the graphite content, *i.e.*, the more carbon that is present in the combined form, the less the graphitic carbon. This fact will be better appreciated if one considers types of cast iron made by other processes than the cupola.

To take black-heart malleable cast-iron. At first sight there is very little similarity between this product and grey cast iron, but fundamentally the irons are not so widely apart. In Table III specific examples are quoted which have been selected on account of their similarity in composition. The material difference lies in the total carbon contents, the grey iron containing 3.24 per cent. and the malleable iron 2.62 per cent. There

TABLE III.—*Relative Properties of Cast-iron and Malleable.*

| | Grey cast-iron. | Black-heart malleable. |
|---|---|---|
| Graphite Carbon .. | 2.68 per cent. | 2.62 per cent. |
| Combined Carbon .. | 0.64 ,, | — |
| Silicon .. .. .. | 1.38 ,, | 0.51 ,, |
| Sulphur .. .. .. | 0.094 ,, | 0.088 ,, |
| Phosphorus .. .. | 0.16 ,, | 0.19 ,, |
| Manganese .. .. | 0.43 ,, | 0.33 ,, |
| Tensile Test (Tons per sq. inch) .. | 15.36 | 23.56 |
| Elongation .. .. | — | 8.5 per cent. |
| Transverse Test. 15 in. × 1 in. × 1 in. | 26 cwts. | — |
| Brinell Hardness .. | 196 | 113 |

is the same amount of graphite in each, the matrix differs in that the grey cast iron has a pearlitic matrix while the malleable has a ferritic matrix. This, however, should theoretically render the cast iron stronger than the malleable, as pearlite has a much higher tensile strength than ferrite. The phosphorus contents are the same. Why, then, the enormous difference in physical properties? Obviously this is due mainly to the nature and distribution of the graphite content. In one, it occurs generally in lenticular tenuous plates, and in the other in a nodular form well intermeshed with ferrite. The photomicrographic appearance of these two particular examples is illustrated in Fig. 1. The fairly obvious fact which is drawn from this comparison is that the nodular form of graphite gives an iron which is far stronger than one in which the graphite is present in lenticular plates. This deduction is well borne out in practical experience that the closer the graphite approaches in form and distribution to that shown by malleable iron, the stronger the cast-iron becomes. Inversely, any iron showing long, large graphite flakes is very weak. There is also another factor which has not received sufficient attention, and that is the structure of the graphite flake itself. *It is not likely that there is any material difference in the actual graphite present in cast irons*, i.e., *that allotropic modifications are present in different irons.* It is, however, extremely likely that what we call graphite flakes are, in many cases, not solely and wholly graphite but graphite intermeshed with ferrite. It is nearly impossible, owing to the difficulties of polishing, to verify this absolutely microscopically, but is very noticeable that graphite flakes in strong cast-iron under the highest powers of the microscope exhibit distinct signs of an internal structure. It is only logical to presume that graphite intermeshed with ferrite will have a much smaller weakening effect than graphite alone. The ideal, therefore, to be aimed at in cast-iron founding is to produce an iron which

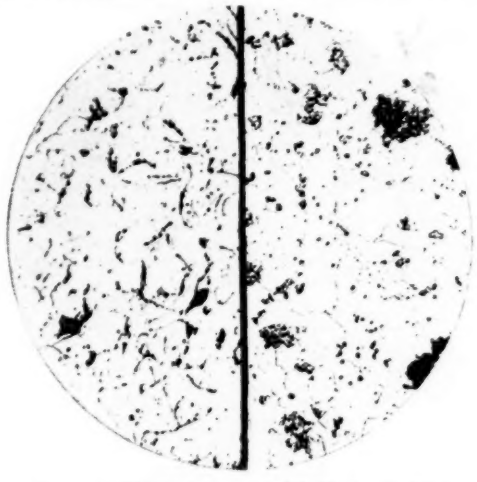


FIG. 1.—MICROGRAPH OF 100 DIAS. OF GREY CAST IRON (LEFT) AND MALLEABLE (RIGHT). THEY BOTH CONTAIN THE SAME TOTAL CARBON.

will have the graphite in exactly the same form as a black-heart malleable cast-iron. If this was achieved, then the resulting iron would have a tensile strength of anything up to 30 tons per sq. in.

Naturally, the questions arise: How is this ideal to be attained? What factors govern the deposition of graphite in the nodular form? Frankly, we do not know. The present state of our knowledge is such that we have only problematical ideas on the subject. It is here that the question of judicious selection of raw materials—pig-iron, scrap, etc.—enters. The components of the mixture for strong cast-iron must be such that the resulting iron will have not only a low-graphite content, but also the graphite must be distributed in a form which closely resembles the distribution of that in black-heart malleable iron, *i.e.*, graphite produced by the decomposition of cementite and pearlite by subjecting white iron to high temperatures. Here we have two essentials, which, of all others, are least under the control of the foundryman. It may be taken as fairly axiomatic that if one starts at the cupola stage with a mixture high in total carbon, one will finish at the spout with a high total-carbon iron, no matter what the melting conditions may be. Inversely, if one starts with a low total-carbon mixture, it is not at all

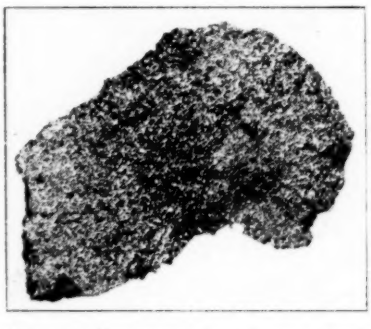


FIG. 2.—FRACTURE OF A SCOTCH PIG-IRON, HALF FULL SIZE. IT DOES NOT CORRESPOND WITH THE ANALYSIS.

certain that a low total-carbon cast-iron will result.

This is well exemplified in making cast-iron containing very heavy steel-admixtures where, unless the melting conditions are very carefully defined, the resulting cast-iron is very high in the total carbon.

### Hematite and "Off Irons."

Consequent on what has been said, it will be appreciated that hematite irons should not be used to any great extent for mixtures for high-grade work. Hematite irons are often a great temptation to ironfounders on account of their low phosphorus content and their cheapness when compared with cylinder and cold-blast irons, that is, they provide the simplest and at the present time decidedly the cheapest method of pulling down the phosphorus content of the lower grades of foundry iron. It should be remembered, however, that hematite irons are produced principally for the acid steel-maker, to whom low sulphur and phosphorus contents are factors of vital importance, and to whom total carbon matters nothing at all. It is quite true that the low total-carbon hematites can be obtained at times, but the irregularity of this element renders the iron of doubtful value. The writer has had consecutive deliveries of hematite iron, though fairly similar in analysis in other respects, vary as much as 1 per cent. in the total-carbon content. The low total-carbon hematite, when obtained, is very often an "off iron," *i.e.*, a production of abnormal working of the furnace. Abnormal irons are always untrustworthy and are a source of constant trouble to the foundryman. It is never good practice to use an iron which is not the normal regular product of a furnace.

### Value of Fracture in a Pig-Iron.

The fracture exhibited by a normally-cooled pig-iron is a very useful guide as to its suitability for various work, if accompanied by the analysis. Without the analysis the considerations of the

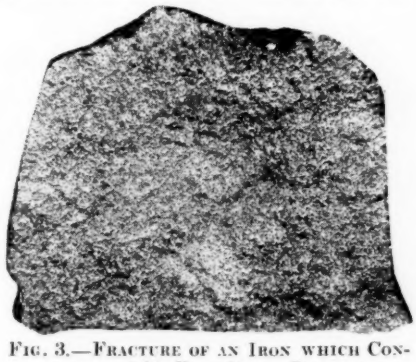


FIG. 3.—FRACTURE OF AN IRON WHICH CONTAINED 4.25 PER CENT. SILICON.

fracture are of little value. One of the fairly well-established axioms is that an open-fractured pig, no matter what the analysis may be, will give an open-fractured casting. On the other hand, a close-grained pig-iron will only give close-grained castings if its fracture corresponds fairly well with its analysis. What is known as a "dry" fracture among foundrymen (though close) should be looked upon unfavourably. A dry fracture may be generally interpreted as one which shows little or no exfoliation, or may be otherwise described as "crumbly" or "short." This type of fracture is, perhaps, seen to its best in a high sulphur (say 0.20 per cent.) fairly low-silicon iron. The large, spangled fracture of the foundry-numbers of hematite iron is, of course, well known, and the peculiar reticulated fracture of the cold-blast irons is fairly easy to identify. The ideal fracture for an ordinary quality of pig-iron for foundry work is one which has a granular structure, which even over the whole section—not close at the outside and open in the centre, but of an even greyness (varying according to its analysis) throughout. While on the subject of fractures, it may be interesting to cite one or two examples of strikingly anomalous fractures presented by pig-irons. Fig. 2 shows a photograph of a fracture of a consignment of Scotch pig-iron of a well-known brand. As will be seen, the pig-iron is very open in character, on fracture would at least pass for a No. 3 with 2.50 to 3.0 silicon. The full analysis showed 3.78 T.C., 3.25 Gr.; 0.53 C.C.; 0.32 Si.; 0.053 S.; 0.242 P., and 0.75 Mn. per cent. This was not a stray piece, but the whole of the consignment of 25 tons was the same. There is nothing in the analysis which could possibly account for the fracture.

Fig. 3 shows the fracture of a sample of pig-iron of a well-known brand. On fracture, this would be graded as a No. 4 or even a No. 5, but actually the analysis showed the silicon content to be 4.36 per cent. silicon. Microscopic examination failed to reveal any signs of the pig-iron being artificially chilled, and the pearlite present was well laminated.

*It is not contended that such striking examples as these are extremely numerous, but the same*

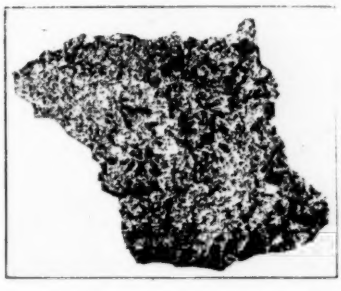


FIG. 4.—SAMPLE OF UNDRILLABLE PIG-IRON OF NORMAL ANALYSIS.

*sort of thing, in a minor degree, is regularly observable by those who study the fractures in conjunction with the analysis.*

One does sometimes get anomalous fractures which can be suitably explained if traced back sufficiently far. Such is the case of a pig-iron the fracture of which is shown in Fig. 4. The analysis was 3.85 T.C., 3.35 Gr.; 0.50 C.C.; 2.04 Si.; 0.023 S., 1.18 P., and 1.83 per cent. Mn. For the sample and details of this pig-iron the writer is indebted to his friend, Mr. W. H. Poole, of the Keighley Laboratories.

This pig-iron, as will be seen, is of quite normal analysis, but yet none of the consignment could be drilled, even with a specially hardened tool. The microscope, in this case, showed the cause of the extreme hardness. As will be seen from the microphotograph in Fig. 5, the structure consists of large graphite flakes embedded in a matrix of a martensitic character, and the usual phosphide eutectic lakes. The martensitic is, of course, the cause of the extreme hardness.

Mr. Poole found that this unusual structure and fracture was due to quenching off the pigs in the bed above the point where the austenite decomposes, but not sufficiently high to prevent the almost complete separation of graphite.

Such a sample would probably, on remelting, give an iron with a structure and fracture com-

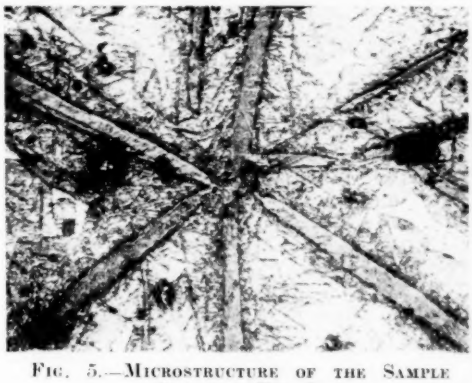


FIG. 5.—MICROSTRUCTURE OF THE SAMPLE SHOWN IN FIG. 3.

parable to the analysis, but it is extremely doubtful whether such would be the case with samples previously mentioned.

### The Fallacy of Relying Wholly on Analysis.

The mixing used for a particular class of work in a foundry with which the writer has been connected consisted of 30 selected home scrap, 10 mild-steel scrap, 20 cold-blast No. 4, and 40 per cent. cylinder pig "X." This mixing, owing to the extreme consistency of consecutive deliveries

of the pig-irons used, shows an almost monotonous regularity in the analysis and test results which are taken daily. On one occasion another cylinder pig-iron, which shall be called "Y," was substituted for "X." The analysis of "X" was 3.06 T.C., 2.53 Si., 0.056 S., 0.62 P., and 1.86 per cent. Mn., and that of "Y" 3.15 T.C., 2.31 Si., 0.070 S., 0.71 P., and 1.45 per cent. Mn. As will be seen, cylinder "X" shows a slightly superior analysis, but there is no very material difference. The difference in price was 27s. 6d. per ton.

Table IV shows the averaged analyses of a standard mixing for the three weeks immediately preceding the introduction of the pig "Y," and the average of the daily physical tests. Two bars showing flaws have been omitted. Alongside are the averaged analyses and physical tests for the

TABLE IV.—*Showing the Influence of Changing a Brand of Iron.*

| | Standard Mixing. (Average 13 Bars.) | Mixing with Cylinder Pig 'Y.' (Average 12 Bars.) |
|---|---|---|
| Total Carbon .. .. | 3.13 per cent. | 3.20 per cent. |
| Graphitic Carbon .. | 2.37 ,, | 2.42 ,, |
| Combined Carbon .. | 0.76 ,, | 0.78 ,, |
| Silicon .. .. .. | 1.32 ,, | 1.25 ,, |
| Sulphur .. .. .. | 0.093 ,, | 0.105 ,, |
| Phosphorus .. .. | 0.65 ,, | 0.71 ,, |
| Manganese .. .. | 0.61 ,, | 0.54 ,, |
| Transverse Test 12 in. × 1 in. × 1 in. | 36.6 cwts. | 29.8 cwts. |
| Tensile Test .. .. | 16.8 tons | 15.51 tons |
| Impact Test .. .. | 23.2 ft.-lbs. | 18.4 ft.-lbs. |

three weeks following, using pig "Y." The difference in the physical tests is quite definite. The behaviour of the metal in the ladle was also very noticeable. The standard mixing was perfectly clean when molten, even at low temperatures, but the mixing containing cylinder pig "Y" clean at a blue-white heat, but as soon as the temperature dropped was very dirty, and scum was continually rising to the top of the ladle. The surface of the resulting casting was by no means as clean, and several important parts machined all over failed to clean up satisfactorily where the machining allowance was small. The fracture of the test bars was also interesting. The standard mixing was dense grey throughout, but the mixing with cylinder pig "Y" showed a tendency to openness at the centre, although quite close on the outside. This example naturally leads to the question of cylinder pig-irons. A great many blast-furnace people seem to think that they have only to cut the phosphorus in their pig to 0.5 per cent., raise the manganese to 1.5 per cent., call it cylinder, and they have iron worth two pounds a ton more than the ordinary grades. The writer can point out at least four specific brands of the so-called cylinder pig which regularly contain 3.5 to 3.6 per cent. of total carbon. A cylinder pig-iron, to be worthy of the name and price demanded, should represent the strict mean between a hot-blast foundry iron and an all-mine Staffordshire cold-blast iron. That is, it should be produced in semi-cold blast furnaces, and have a total carbon not exceeding 3.2 per cent. when the silicon is from 1.0 to 2.0 per cent. Also, it should be regular in composition. An iron which is irregular in composition is a perfect nuisance, and necessitates constant manipulation of the mixing, *i.e.*, juggling with the amounts of the various components. No iron is worth an enhanced price unless it is definitely regular in every respect.

### Cold Blast Irons.

When one touches on cold-blast iron, it is reviving old memories for many foundrymen, for it is now only a memory to many people. The present depression and the high price has nearly killed the use of, if not the faith in, cold-blast iron, but the essential fact remains. One cannot get as good cupola-melted cast-iron without cold-blast iron as with it. This is stated quite dogmatically and without quibbling. The writer, in stating this, does not refer to any particular physical characteristic of cast-iron, but to all-round general properties. The nodular form of graphite is more well developed in cupola-melted cast-iron containing cold-blast than in any other.

The statement that the working temperature of a blast furnace, apart from the analysis of the finished pig-iron, has a profound effect on the graphite structure which persists, even after remelting in the cupola, is one which is deserving of serious consideration. Admittedly no tenable theory has yet been propounded to explain this phenomena or even as yet no thoroughly unchallengeable experimental data to support it has been given.

This position is, however, only in line with practically all our other knowledge, *i.e.*, we know the effect nearly always before we know the cause.

### Electric Furnace Cast-iron.

The writer had the opportunity some few months ago of running several heats of cast-iron in an electric furnace, and the results were so remarkably good and illustrate so well many of the points which he has attempted to bring out in the Paper that no apology is offered for giving a *précis* of the results here. The furnace was an arc furnace of the Heroult type and acid-lined. The materials charged varied, as is shown in Table V, and no attempt at refining was made, the materials being merely melted under a lime slag. The figures given cannot be supposed to represent finality, as these were all experimental runs. The final composition of Charge No. 3 was made by making the necessary additions to a steel bath obtained by melting borings. The low total carbon is very significant, and although the combined carbon is only 0.26 per cent., the tensile strength reached 17.10 tons per sq. in. The writer has never seen any data from cupola iron showing such remarkable figures for high silicon, low combined carbon iron. The low graphitic carbon is undoubtedly the main cause of the high-test figures, coupled with higher casting temperature and general greater cleanness of the iron. The second example quoted, Charge No. 7, was run with a lower silicon-content but with a higher phosphorus. The results in this case demonstrate the value of a low total-carbon and the unimportance of combined carbon *per se* as affecting strength.

The last example, Charge No. 4, gives a higher test-result that the writer has ever seen for the same silicon content. Here the total carbon was down, and the graphitic carbon at an extremely low figure, and the iron was only machined with great difficulty.

### Steel as a Pig-iron Substitute.

The experiences of ironfounders in the use of steel scrap as a component of cast-iron vary very widely from wholesale condemnation to wholehearted praise. The great variations in results are chiefly due to variations in melting conditions.

TABLE V.—*Electric Furnace Heats.*

| Heat No. | 3 | 7 | 4 |
|---|---|---|---|
| T.C. .. .. .. .. | 2.71 | 2.89 | 2.91 |
| Gr. C. .. .. .. .. | 2.45 | 2.53 | 2.19 |
| C.C. .. .. .. .. | 0.26 | 0.36 | 0.72 |
| Si. .. .. .. .. | 3.15 | 2.64 | 1.86 |
| S. .. .. .. .. | 0.086 | 0.092 | 0.10 |
| P. .. .. .. .. | 0.093 | 0.868 | 0.36 |
| Mn. .. .. .. .. | 0.71 | 0.53 | 0.41 |
| Tensile Test, in tons per sq. in. on 1 in. dia. cast bar .. .. | 17.10 | 16.60 | 18.6 |
| Transverse Test, in cwts. on 15 in. × 1 in. × 1 in. cast bar | 38 | 41.2 | 47.0 |
| Deflection in ins. .. .. | 0.19 | 0.14 | 0.18 |

NOTE.—Cast No. 3 is made from steel scrap, silico spiegel, ferro-silicon, and graphite; Cast No. 7, from No. 1 Pig, steel and ferro-silicon, and Cast No. 4, from steel scrap, ferro-silicon, spiegel and graphite.

Speaking strictly from personal experience, the writer has found that with ordinary rapid melting-practice, uniformly good all-round results cannot be obtained from cast-iron containing more than 20 per cent. of steel. If it is desired to incorporate more than this percentage of steel in the iron, then the best practice is to run a high-percentage steel-mixture into pigs and remelt. Naturally it is more economical to purchase such a refined pig-iron from large makers. Refined pig-irons are generally produced in a similar manner, i.e., by melting steel scrap with pig, though more often not in the cupola.

**Summary.**

To summarise briefly the main points which the writer has endeavoured to bring out:—

(1) Pig-irons should be selected which will give the correct analysis in the finished casting, but it should be remembered that correct analysis is only about half the battle.

(2) Brands should be selected which experience has shown are associated with clean melting, close grain and high strength and which are regular in composition.

(3) Open-grained irons and abnormal irons, such as "over greys," etc., should be avoided despite their analyses.

(4) Keep the total carbon as low as possible and use low total carbon pigs, *i.e.*, cold-blast and semi-cold blast.

In conclusion the writer would like to point out that the present stage of our knowledge is so imperfect that we cannot afford to neglect any factor in the production of cast-iron. No one can yet reject any phase in cast-iron production from the mine to the fettling shop as being unimportant and without bearing on the final product. There is no doubt that as our knowledge increases the factors affecting the strength and casting properties of cast-iron will be more clearly defined, and certain variations in treatment will be found to have no bearing on these properties, but it is also extremely likely that variations, to which little attention is now paid, will be found to exert a profound influence. It is only, therefore, by paying attention to every side of the question with an unprejudiced mind that we can hope to progress in the knowledge of that extremely complex material—cast-iron.

## Reverberatory Furnace Manipulation.

By "CELSIAN."

The reverberatory furnace most commonly used is provided with a fireplace, sloping hearth, and a well for the collection of molten metal. This coal-fired furnace has no pressure exerted on it, the stack being responsible for drawing the gases from the hearth, the burner forcing the gases out of its own heating chamber.

The flame from the fuel is deflected by the arched sloping roof upon which it impinges on to the material placed upon the hearth beneath.

To secure satisfactory results, the flame should cover the whole width of the bed equally, if the furnace has been correctly fired, and take the form of a large blanket.

No exact rules can be laid down on how to manipulate successfully a reverberatory furnace.

The guidance of the inexperienced can only be made by constant experimenting in each individual case.

The uncertainty of working these furnaces will be understood when it is stated that half-a-dozen in the same yard, constructed from the same plan, and apparently identical in every degree, may produce entirely different results, although exactly similar conditions are adhered to. Generally speaking, a large flue will cause a greater consumption of fuel and a much more rapid attainment of high temperatures.

When a certain limit has been overstepped, however, the fuel is burned without a corresponding rise in temperature. The draught is regulated by means of a damper, either in the flue or on top of the chimney.

Melters often economise the amount of fuel used by throttling the flue to the greatest possible extent compatible with the rapid production of the required heat.

To secure the best results the flue should be narrowest at its junction with the furnace, and extend considerably as it enters the stack. The area of the former is usually about 50 per cent. of the latter.

Alteration of the size can be made by adding or removing a little sand at the end of the flue nearest the furnace. One of the flue slabs is removed and then covered up for this purpose. These experiments in altering the area of the flue should make some marked effect which will assist in guiding a furnaceman how to work the furnace on future occasions.

One melter economised in fuel by allowing some clinker to accumulate in the fireplace, forming a thick bed, but allowing space for the necessary air to enter to sustain combustion. By this means small coal could be burnt, which would fall through the bars of an ordinary grate.

The fuel used was a mixture of two parts of free-burning to one part of binding coal.

In passing through the bed of clinkers the oxygen of the air becomes heated before combustion takes place.

Not only is the weather and force of the wind responsible for unexpected changes, but the condition of the atmosphere often produces an entirely different impression from what might be expected.

These atmospheric changes can often temporarily undo the advantages gained by altering the flue area, and their influence is often not realised until after many charges have been worked. When high temperatures have been used for continued periods, the effect on the brickwork is often remarkable. Great stalactites of plastic firebrick hang downwards from the arch over its entire surface.

Not only are the side walls glazed, but they are fused sometimes to a considerable depth.

The formation of this hard, glistening, semi-fused mass must be examined with care, but so long as no cracks appear, little harm will have been done. The surface of the hearth is sometimes strewn with fragments of brick from the crown, and also little heaps of fireclay.

Blisters and irregularities may be overlooked, as the upper hearth has really to bear the brunt of the attack. An experienced furnaceman constantly watches his furnace with regard to the conditions and safety of its bottom. After firing for some time on a fresh charge a rabble is introduced, and by the feeling of the sand when gliding over the bottom the condition of things is at once determined.

If sticky and slippery, it shows that portions of the charge still adhere to the hearth. After removing these with a rabble, they are dissolved by raising the temperature slightly. This is continued until the rabble glides smoothly over a plane, granular bottom.

When this condition has been attained, maintaining the charge at a high temperature is not only a waste of fuel but is detrimental to the structure of the hearth. An equally detrimental action is caused when a high temperature is maintained with a small charge, as unprotected portions of the bottom may become so softened as to rise in parts and allow the molten metal to flow underneath.

To maintain satisfactorily a good bottom the furnace must be properly fettled after each heat if it shows any signs of weakening. The life of the side walls also depends on the care which is bestowed on the fettling.

One of the best fettling mixtures which has been used for many years and still is employed consists of pure white quartz, crushed through a three-mesh screen and mixed with sufficient fireclay to form balls. These are placed at exactly the required point and forcibly pressed and moulded as desired. Quartz may be replaced by ordinary bottom sand, but the latter is less solid and permanent.

Buck stays should be made of steel, not cast-iron, as was used in the older classes of furnace, the iron cracking too readily when working the charge at different temperatures.

The atmosphere produced will depend to some extent on the depth of fuel on the grate, and when this is present in large quantities, incomplete combustion will be effected.

In this manner carbonic oxide and free hydrogen will be formed which produce a reducing flame. A hot oxidising flame may be produced by using a thin layer of fuel and a good draught.

VICKERS, LIMITED, have launched from their Naval Construction Works at Barrow only one vessel during this year, the steam collier "Helmwood," for W. France, Fenwick & Company, with a gross tonnage of 2,183. The company have built a set of Diesel engines for a cargo boat for Japan, the total horse-power constructed being 1,650.

## "Armco" Welding Electrodes.

Already a great deal has been written concerning what is now commercially known as "Armco" quality ingot iron, an iron practically free from impurities, especially manganese. The British licensees under the patents for the manufacture of this iron—The Shelton Iron, Steel & Coal Company, Limited—made their first heat in 1913. Naturally this was more or less in the nature of an experiment; it proved, however, a signal success, and since this initial venture the manufacture of this iron has been a staple production of the Shelton Company. Hundreds of tons of the billets so manufactured have been rolled into rods and successfully drawn into wire for electrical and other requirements by the Whitecross Company, Limited, Warrington, the British licensees for that purpose.

In this article, however, we do not propose to enter into a general consideration of the properties of "Armco" ingot iron, but rather to confine ourselves to dealing with its possibilities for welding electrodes, a field of usefulness which is now being developed by the Whitecross Company. The first essential of a good weld is a suitable welding wire, and such a wire must be free from impurities such as sulphur, phosphorus, slag and oxides, whilst there must also be a fine limit in regard to carbon, manganese, and silicon content. It must not be forgotten that the skill of the operator is confined to an adjustment of the arc and reshaping or adjusting of the surfaces to be welded, so that a weld free from pin-holes, soft, hard or brittle spots is only obtainable by a suitable free-flowing electrode. It will be noted from the following typical analysis of "Armco" ingot iron made by The Shelton Iron, Steel & Coal Company, Limited, that the iron from which the welding wire is manufactured is of a purity surpassing Swedish charcoal and other brands of nearly pure iron:—Carbon, 0.020 per cent.; manganese, 0.049 per cent.; silicon, trace; sulphur, 0.016 per cent.; phosphorus, 0.014 per cent.; copper, 0.023 per cent.; arsenic, 0.011 per cent.; oxygen, 0.024 per cent.; total impurities, 0.157 per cent.; iron (by difference), 99.843 per cent.

It is sometimes argued that the welding rod must be of a composition having as nearly as possible the same characteristics as the material to be welded. In a few special cases it may be advisable to use rods of a particular composition, but as it is often neither possible nor practical to determine the exact composition of the material to be welded, it would seem that preference should be given to a wire of a single standard analysis and texture, which will give in all cases a weld free from pin-holes, blowholes and brittleness.

Apart from the all important question of purity, the "Armco" ingot-iron electrode differs from mild steel in that with D.C. welding it is possible to produce a good sound weld by the use of bare wire, with consequent saving in cost over coated wires. The use of bare "Armco" wire is the general practice in the United States. At the same time it is admitted that it is more difficult to preserve the continuity of the arc with the bare than with coated electrodes. In this country, however, operators are accustomed to the coated wire, for which reason and because in the case of welding with A.C. current, the very small variation of arc permitted makes it impossible for the operator to preserve continuity, except with the help of flux coating, the "Armco" ingot-iron electrode is now supplied flux-coated.

The particular flux is the outcome of many years' study and experiment. In the first place it is entirely free from carbonates, the fusion of which, as is well known, liberates carbon dioxide gas. The coating leaves on the weld a thin brittle covering of slag easily removed with the tap of a light hammer, and if it is so removed before going over a weld a second time, there is no possibility of slag inclusion in the weld. The bare electrodes are manufactured for use with carbon arc processes, for welding heavy plates or flanges and for filling holes in castings; they are also supplied on reels for use with automatic welding machines.

## The "Motorailer" Wheel.

Some very satisfactory tests were recently carried out with a convertible type of motor wheel which in a few minutes can be adapted to either rail or road use. The tests were made on a heavy lorry of the four-wheel drive type. In the standard design, the motor wheel is of rail-track type made of high-carbon steel. To convert this for road traction a cast-steel rim with a ¼-in. gap cut out of it in the way common with piston rings, is placed around the wheel to provide the requisite horizontal face for the rubber tyre. This loose ring is held in position by six

FIG. 1.—FIXING THE RIM FOR RUNNING ON RAILS.

¾-in. hardened-steel bolts with a sector-shaped head which engages in the milled slots in the ring. Fine threads are used, and as far as present tests show there is no need for a special locking device. To facilitate the removal of the tyre, a number of channels are cut into the split rings, and into these grooves are fitted V-shaped blocks, each provided with a strong setscrew. These blocks take a bearing on the fixed wheel, and if the setscrews be tightened up, the split ring is withdrawn sufficiently to loosen it in the tyre band.

In the tests the lorry equipped for road use was aligned on the railway track at a level crossing, the wheels jacked up and the four loose

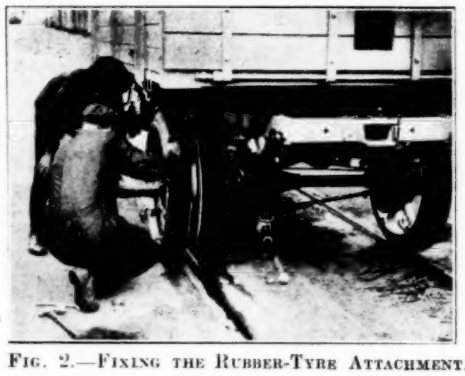


FIG. 2.—FIXING THE RUBBER-TYRE ATTACHMENT.

rims and solid rubber tyres removed within the space of about 8½ min. After demonstrating the running capabilities of the vehicle on rail, the rubber tyres were again put on, the time taken for replacement being about half an hour. The device is manufactured under the patents of General Sir H. C. Holden, by the Motorailer Transport Company, Limited, of Avenue House, 21, Northumberland Avenue, London, W.C.2.

THE IMPORTS of foreign iron-ore at the Senhouse Dock at Maryport during November amounted to 3,500 tons, compared with 7,900 tons for October and 3,000 tons at the corresponding period of last year.

THE VICKERS-SPEARING BOILER COMPANY, LIMITED, of 20, Kingsway, W.C.2, were, recently, successful in securing a contract for the second section of extension of generating plant, consisting of four large water tube boilers of the Spearing type, for the Leicester Corporation Electricity Works.

# An Apprenticeship Course in Foundry Practice.—LXVIII.

By Ben Shaw and James Edgar.

## STORING PATTERNS.

The storing of patterns can be truthfully regarded as an important part of the trade of the foundryman. The ideal system has not yet been found, and probably never will be, for the very obvious reason that the methods adopted are usually the result of many years' experience. In new works a system has to be decided upon, but in the case of most foundries and pattern-shops storing methods are gradually improved until, to the uninitiated, what is really a simple system seems exceedingly complicated. It is a much easier matter nowadays to organise a pattern stores than it was twenty years or more ago, because it is generally recognised that almost as much attention should be given to the design and layout of the pattern store as to the pattern-shop itself. The subject is one that is of almost equal importance to the foundry as to the pattern-shop, because, in both departments, unless some good system is in operation, much labour is wasted searching for lost patterns. The modern pattern store is a fireproof building, with well-lighted corridors and racks of convenient width, so that the patterns can be obtained without much searching.

There is a considerable difference between the pattern store and the tool and jig stores of the metal-working shops, because there is often a choice of pattern that can be used; therefore, it is essential, or at least advisable, that pattern-makers should have access to the stores, even if they are prohibited from removing patterns without the storekeeper's or foreman's permission. There are many pattern-shops at the present time where there is practically no system, reliance being placed upon a storekeeper's memory. Even in small shops, some system is desirable, and is quite possible. But it may be said that a bad system thoroughly understood by all who have to work it, is better than a good system imperfectly understood.

In the maintenance shop of, say, a textile mill, a very simple system is satisfactory, but something more is required in a works doing all types of jobs or in a foundry where patterns are being delivered from many firms and which have to be returned in good condition. It is quite impossible in the compass of one article—it would be for that matter in a series of articles—to discuss the many systems in operation to-day, and it is not contended for those that are explained that they are perfect or the best that can be adopted. The purpose of this article will be achieved if an understanding of the principles of storage are obtained by our readers, and if they become impressed with the importance of the subject and the need for giving to it close attention and study.

### Storage Systems.

The storage systems in use to-day may be divided into four categories. The first of these is scarcely worthy of the name of system, in which reliance is placed on one man's memory and in connection with which no books are kept. The second is the method of recording the history of the patterns in a book, a fresh entry being made each time a pattern is received or sent out. The third method is the card-indexing system, and the fourth is a combination of the book and card index. The first may be dismissed as unworthy of consideration; the second cannot be recommended unless in very small shops or where only a few classes of work are produced. The third system is perhaps the best, although there are circumstances in which the record book and card-indexing cabinet can be effectively used together.

### Card Indexing.

We shall discuss the card-indexing system for pattern-shop use first. Form 1 shows the card suitable for adoption where the patterns are stored according to number. It will be observed that the number is in the left-hand corner, and the name or description of the pattern follows. This card provides a complete record of the pattern, but the information it contains could probably be modified for different pattern-shops. On the pattern is stamped the number indicated at the top left-hand corner of the card, and when this pattern is required at any time, the drawing office state the pattern number on the blue print.

When the pattern is at the foundry, this card is in the possession of the storekeeper, but when it is in the pattern-shop, it is filed in a cabinet usually in, or adjacent to, the foreman's office. Thus, if a pattern is required at any time and the card is missing from the indexing cabinet in the pattern-shop, it ought to be found in the store cabinet, stating to which foundry it has been sent. If the pattern cannot be traced from the card, the storekeeper is at fault. When this system is properly organised, it should be possible to locate and obtain a pattern in two or three minutes. In a large works, where there are almost innumerable patterns, it may be necessary to use alphabetical letters as well as numbers, thus A.345, A.346, etc. On the other hand, numbers may be dispensed with altogether and the jobs indicated as at Form 2 by the cards being placed in the cabinet in alphabetical order. This latter method is more likely to cause delay in finding patterns, as there may be several patterns of the one size, but of slightly different design, and it would consequently be necessary to compare them all with the new drawing to ascertain which was required. It will be noted that in these cards the name of the foundry to which the pattern is sent is written, and the foreman pattern-maker is responsible for the dispatch of the patterns. In the first column the material of which the pattern is made is given, but this column is only necessary in shops where there are iron and other metal patterns. It is advisable to keep a record of the number of core-boxes that are sent out, and here it may be said that these cards should not be made up until work is actually on the way to the foundry. Only in this way can the foundry be fairly held responsible if a complaint is received that there is a core-box short. In the column "Where Stored," A represents the floor of the pattern stores in Form 1, 12 is the rack number, and 6 is the section of the rack. In some stores the floors are not numbered, but the sections are numbered from 1 upwards, and, while on the bottom floor the sections may be from 1 to 100, on the second floor they would be from 100 to 200, and so on. It is usually customary to store the heavy patterns on the ground floor and the lightest patterns on the top floor.

A system which is sometimes advocated is the division of the pattern stores into two distinct parts, one part being allocated to out-of-date patterns and the other to up-to-date patterns. This makes any system needlessly complicated, besides which it is usually very difficult to decide which are out-of-date and which up-to-date patterns. Even the drawing office cannot offer satisfactory guidance on this question. It might be easier to make two divisions, one being for standard patterns and the other for work which may not be required again. But when the proper numbering card system is in use, no advantage whatever can be gained by differentiating between one class of patterns and another.

### Card Indexing and Record Book Combined.

In addition to the card for the patterns which are at the foundry which the storekeeper files, he may use a record book as an additional check upon himself, which obviates the necessity of him referring to the pattern-shop cards, if at any time he wishes to trace the whereabouts of a pattern. Form 3 illustrates a page of a record book suitably columned. In some cases a separate book is kept for each foundry to which patterns are sent,

XUM

FORM I.

| 260—3 in. Handwheel | | Pattern sent to | *A. Jones & Co.* | Date, 3rd Feb., '23 | Foreman's Signature | *T. Thompson.* |
|---|---|---|---|---|---|---|
| Material of which made | Core-boxes | Name of part | No. off | Foundry Order Number | Where stored | Material |
| *Brass on Plate, 6 patts.* | *3* | *1 in. valve* | *24* | *6532* | *A—12—6* | *G. M.* |
| | | | | | | |
| | | | | | | |
| | | | | | | |

Pattern Returned 6–6–23
Storeman's Signature, *T. Smith*

FORM II.

| Handwheel—3 in. | | Pattern sent to *A. Jones & Co.* | | Date, 3rd Feb., '23 | Foreman's Signature | *T. Thompson.* |
|---|---|---|---|---|---|---|
| Material of which made | Core-boxes | Name of part | Number off | Foundry Order Number | Where stored | Material |
| *Brass on Plate, 6 patts.* | *3* | *1 in. valve* | *24* | *6532* | *A—12—6* | *G. M.* |
| | | | | | | |
| | | | | | | |
| | | | | | | |

Pattern Returned, 6–6–23.
Storeman's Signature, *T. Smith.*

FORM III.

| Name of part | Sent to Foundry | Returned from Foundry | Condition when Returned. | Number of Core-boxes | Core-boxes Returned. |
|---|---|---|---|---|---|
| *4 in. S.D. Valve* .. | *1st Jan., '22* | *3rd Mar., '22* | *2 in. Branch lost* | *2* | *2* |
| *L. P. Cyl. (893)* .. | *8th Jan., ,,* | *3rd May, ,,* | — | *12* | *12* |
| *6 in. C. I. Pipe* .. | *15th Jan., ,,* | *14th May, ,,* | *2 ribs missing* | *1* | *1* |
| *Bedplate (35)* .. | *1st Feb., ,,* | *3rd June, ,,* | — | *7* | *7* |
| *Gear Case (63)* .. | *3rd Feb., ,,* | *25th May, ,,* | — | *8* | *8* |
| *12 in. Piston* .. | *5th Feb., ,,* | *14th June, ,,* | — | *1* | *1* |

FORM IV.

PATTERN CARD (Iron).

*Shipyard.* Order No. *543.*
Pattern sent to *T. Johnson & Co., Ltd., Tipton.* Foundry.
Pattern Shop Signature *M.S.L.* Date *3 Sept, 1922.*
Description *6 in. S.D. Valve.*

| .....Core Boxes | .....Sweep Boards | .....Gauge Sticks | .....Strickles | .....Drawing Boards |
|---|---|---|---|---|

| Pattern No. | Name of part. | No. Off. | No. Of Order. | Conveyance. | Where Stored. | Drawing or Sketch No. |
|---|---|---|---|---|---|---|
| *3452* | *Chest* .. ..<br>*Cover* .. .. | *3*<br>*3* | *2245*<br>,, | *Rail* | *A—5—6* | *6783* |
| | | | | | | |
| | | | | | | |
| | | | | | | |

Patterns Returned *4 Dec., 1922.*
Stores Signature, *L.T.D.*

FORM V.

*ARKWRIGHT AND CO., BATH.*

| Description | Order No. | No. off | Pattern Received | Order Completed | Where stored | Pattern Returned |
|---|---|---|---|---|---|---|
| *12 in. Handwheel* | *530* | *12* | *1st May* | *30th May* | *A.—25* | *6th June, 1923* |
| | | | | | | |
| | | | | | | |
| | | | | | | |

Workman, *M. Clarke.*

and in other cases a separate book or books are kept for steel, iron, brass and aluminium. If considered necessary at all, as a convenience for the storekeeper, one book is sufficient. It is worth while to consider the various column titles. In the first column is the name of the work, and in the second column the date in which it was sent to the foundry. This is the important column for back reference. Whenever the storekeeper wants to know anything about a pattern as it was returned, he traces it by means of the date. In the next column the date of return is noted, and, as patterns are not always returned in good condition or complete, it is advisable to note the condition in a special column. By so doing the pattern-shop protects itself if the work is urgently required in future and repairs have to be effected, and also there is less possibility of the mistake occurring through a pattern being sent to a foundry with a small boss or rib missing. The number of core-boxes is an additional check on the indexing cards.

**Storing Standard Patterns.**

With regard to standard patterns, there need be no difficulty in storing them so that they can be located quickly. It often happens, and this is especially true of valve work, that the same patterns for mountings are used for several different valve chests. It is customary to store these mountings separately from the chest patterns, and it is sometimes simpler, when the numbering system is adopted for all other patterns, to index such standard patterns alphabetically.

**Modified Card Indexing,**

Another form of pattern card which is sometimes used is shown in Form 4. It will be noted that this is for iron work, and this system makes it advisable to have different coloured cards for steel, iron, brass and gun-metal, and these different coloured cards are stored in separate cabinets. While patterns are still indicated by number, the card is really traced by the date. Thus, the drawing office informs the pattern-shop of the last occasion when the pattern was used, and by referring to the old drawing the dates of construction are found. It is then a comparatively simple matter tracing the card in the cabinet and locating where the pattern is stored. It will be noted that on this card the foreman or his assistant pen their initials when work is sent out, and the storeman signs at the foot of the card before returning it to the pattern-shop. In another system the patterns are numbered according to the year in which they were made, thus patterns made in 1923 would be numbered 2,315, 2,316, 2,317 and so on. This, in the writer's opinion, is a more involved method than the plain numbering system.

Casual patterns and plant repair patterns should not be placed in a separate category, and it is advisable the pattern-shop should know exactly where they are, even if it is the intention to destroy them immediately satisfactory castings have been obtained. In this way vacant numbers are made, but these can be ignored. It is not always possible to store core-boxes along with their patterns. Plate patterns, for instance, are stored in special racks, resting on their edges, and it is therefore necessary to separate the boxes, but it is still advisable to keep the pattern and core-boxes on the same card, entering them as separate items. In some pattern-shops a double card-indexing system is in use, patterns being entered according to number, in one case, and according to the class to which they belong in the other. This is neither advisable nor sufficiently simple to guarantee that mistakes will not be made.

**Storage at the Foundry.**

In the jobbing foundry, more even than in a foundry that specialises in a certain class of work, it is necessary to catalogue in some way all patterns as they are received from customers, and also to keep a record of the date on which they are returned. Form 5 shows a very useful card for this purpose, because, in the foundry, as in the pattern-shop, the card system is preferable to a record book. Foundries do not always look favourably on any systematic method of cataloguing their customers' patterns, and, in many cases, do not provide any store accommodation other than an open yard. Patterns may be kept for many months after they have been finished with, or, indeed, until a customer demands their return, and then it may take a labourer several hours to find the patterns or the foreman moulder himself may have to give time in searching for them that could be more profitably employed. It is usually advisable to adopt alphabetical indexing in the foundry. At Form 5 it will be observed that the customer's name is on the top left-hand corner, and when the pattern has been received into the foundry, the date is entered. If the person responsible has not stored it after the number of castings required are made, the fact is easily discovered, on reference to the card, when a request for the return of the pattern is made by the customer. On the other hand, once the system is in good working order, mistakes like this seldom occur, and if the complaint is made by the customer at a subsequent date that patterns have not been returned, reference to the card at once shows where the responsibility lies or if the customer is making a mistake.

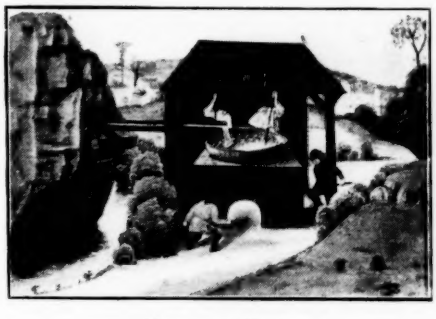
The apprentice will be amply repaid for time given to gaining a knowledge of the storing of patterns. Too much emphasis cannot be placed on the fact that, whatever system is adopted, modifications must be made to suit the particular class of work and the conditions prevailing. Any system depends for its success very largely on the co-operation not only of the foreman and the storekeeper, but of every man and boy in the shop, even if they are not directly responsible for the actual storing of the pattern.

## Medieval Smelting.

In a fine large volume of the 15th century in the Department of MSS. in the British Museum, are various curious and interesting pictures, a photographic reproduction of one of which is included in this article. The original picture is intended to illustrate the accompanying text on the extraction of ore.

The text refers to "stones which by force of fire are converted into metal" [arain].

The artist, so far as we may judge by our present systems, does not appear to have been well



A MEDIEVAL FURNACE.

acquainted with either furnaces or the methods for smelting in use in his time, unless these must have differed widely from those we have reason to believe to have been common in his day. The picture is, however, of value and interest, as it shows a furnace of some sort and the dress and activities of those working round it. Two men appear to be stoking, whilst two others are depicted as vigorously stirring the contents of the cauldron, the contents of which appear to consist of water and lumps of black ore (for the picture is in glowing colours).

OWING to the termination of the partnership of Pattinson & Stead, by the death of Dr. J. E. Stead, senior partner, the business in future will be carried on under the same title and with the same staff as heretofore by Dr. Stead's son, Mr. F. A. Stead. The latter is joined in the partnership by his father's former chiefs of staff, Mr. E. W. Jackson, and Mr. A. Scholes, both of whom had formerly a direct interest in the firm, with which they have been connected for nearly 30 years.

## Trade Talk.

LAUGHLAND, MACKAY & COMPANY, LIMITED, have removed to 9, Fenchurch Avenue, London, E.C.3.

EVANS, DAWSON & COMPANY, iron, steel and general merchants, 13, Bowlalley Lane, Hull, have removed to Prospect Chambers, Bondgate, Darlington.

THE SLAG REDUCTION COMPANY, LIMITED, have removed from 5, Palace Street, Buckingham Palace Road, London, S.W.1, to 24, Denison House, 296, Vauxhall Bridge Road, London, S.W.1.

IMPROVEMENTS are shortly to be started by Needham Brothers & Brown, Borough Foundry, Pontefract Road, Barnsley. A new building, 60 ft. by 45 ft., to be used as a brass-finishing shop, will be the first work put in hand.

THE Board of the Luossavaara Iron Ore Mining Company, which is affiliated to the Graengesberg Company, reports a net profit for the year ending September 30 of £573,958. The quantity of ore exported amounted to 3,578,000 tons, compared with 4,283,000 tons for the previous year.

THE members of the Junior Institution of Engineers visited the demonstration rooms of the British Thomson-Houston Company, Limited, recently, to hear a lecture and witness demonstrations of industrial and shop-lighting effects, by Mr. W. Miller, illuminating engineer of the company.

DR. F. S. SINNATT, of the Manchester School of Technology, director of research in the Lancashire and Cheshire coalfield, lectured on "Some Aspects of the Scientific Study of Coal," before the members of the West Cumberland Society of Chemists and Engineers and others interested in the coal industry, in the Workington Technical College.

THE ORDERS FOR locomotives and wagons for the L. & N.E.R. have now been allotted to the various shops of the company, but those to be built by private firms have not yet been given out. The work for the company's shops has been allotted as follows :—Locomotives.—Doncaster : Twenty "Pacific" locomotives and 12 passenger tank engines ; Darlington : Ten 0-8-0 3-cylinder mineral engines (N.E. type), and 50 2-6-0 3-cylinder goods engines (G.N. type). Wagon :—Faverdale (Darlington) : 4,500 open 12-ton goods wagons, 1,250 end-door 12-ton mineral wagons, 500 20-ton mineral, 1,350 15-ton mineral, 300 10-ton perishables ; Doncaster : 1,000 12-ton open goods, 250 10-ton covered fish, 500 12-ton covered goods ; Dukinfield : 500 double bolster, 1,750 12-ton end-door mineral, and 100 20-ton goods brake vans ; Stratford : 550 cattle wagons ; Cowlairs : 200 12-ton open goods.

THE DIRECTORS of Richard Thomas & Company, Limited, in their annual report, mention the purchase of the ordinary shares of the Grovesend Steel & Tinplate Company, Limited. It is stated that 374,988 ordinary shares of Richard Thomas & Company, Limited, are being issued credited as fully paid in part payment of these shares. In order to provide the necessary additional capital to complete the purchase, the directors have recently offered to the ordinary shareholders 438,666 preference shares and 219,333 ordinary shares at par. The whole of this issue was taken up, with the exception of 11,502 preference shares and 5,751 ordinary shares. The latter have been taken up by some of the directors, who undertook this responsibility before the issue. The directors have appointed Mr. H. Folland and Mr. W. J. Firth, the chairman and vice-chairman of the Grovesend Company, directors of Richard Thomas & Company. They have also appointed Mr. Thomas Ivor Jones, an additional director, and a managing director.

AT A MEETING of the Yorkshire Institution of Mechanical Engineers, held in Leeds, Professor Charnock, of the Bradford Technical School, was nominated president for the next session, and Mr. C. L. Hinings, hon. secretary. The three retiring members of the committee, Messrs. G. L. Murray, S. Moorhouse, and Major F. L. Watson, M.C., were again nominated. The branch welcomed the presence of Sir John Dewrance, the President of the Institution of Mechanical Engineers, who, in his remarks, recalled the association between his father and George Stephenson, the founder. Probably the genesis of the Institution was the meeting at which these two men discussed the question of the locomotive blast pipe, which resulted in its recognition as a means of increasing steam raising power. Sir John emphasised the necessity for close co-operation between this and other engineering societies in research, and in the advancement of the science. Mr. Fred Clements, chairman of the Yorkshire branch, delivered an address on "The Forces of Nature in the Service of Man."

MR. M. E. DENNY, of Dumbarton, speaking at the annual dinner of the Glasgow and West of Scotland Association of Foremen Engineers and Draughtsmen, held in Glasgow recently, remarked that, while it was impossible to view the present shipbuilding position with equanimity, they had every reason to believe that it would not exist for ever. But even if trade assumed its pre-war volume they must remember that many of their Colonies were endeavouring to render themselves independent of us so far as engineering products were concerned. He thought that to meet this competition we must try to retain and improve upon our position in a technical sense and strive to consolidate our progression by co-operation throughout the whole industry. Referring to the internal combustion engine, which was developed on the Continent, he said no one had done more than Lord Pirrie in its application to British ships, and that was an instance of what he meant by keeping in front technically. He was confident the future held as great developments, and it was up to them to see this country did not allow the torch of technical superiority to pass from her hands.

## Contracts Open.

**Aldershot,** December 31.—Necessary steelwork required for the erection of a gantry (British standard sections). Mr. J. Neave, borough surveyor, Municipal Buildings, Aldershot.

**Johannesburg,** January 7.—6-in. and 3-in. black wrought-iron piping, for the Municipal Council. The Department of Overseas Trade.

**Cairo,** February 5.—According to Reuter's, the Director-General, Mechanical Department, M.P.W., Cairo, is inviting tenders for the supply and erection of pumping machinery required for Qassassin Pumping Station.

**Gainsborough,** February 11.—Engine and pumps for raising water from artesian borehole, for the Urban District Council. Mr. S. W. Parker, waterworks engineer, Council Offices, Gainsborough.

**Georgetown, British Guiana,** January 1.—Supply and erection at Georgetown, of one 250-h.p. crude oil engine and centrifugal pumping set, two 150-h.p. similar sets, and one 100-h.p. similar set. H. Howard Humphreys & Sons, consulting engineers, 28, Victoria Street, Westminster, London. (Fee, £10 10s., returnable.)

**London, S.E.,** December 28 and January 14.—The Director-General, India Store Department, Branch No. 14, Belvedere Road, Lambeth, S.E.1, invites tenders for (1) turbo-alternator set, condensing plant, cranes, boiler, economiser, pumps, steel chimney, steam and exhaust pipework, switch-board, motor converter set, rotary converters, sub-station plant, extra-high-tension feeder cables and auxiliaries ; (3) steel tyres for railway carriages and wagons.

**London, S.W.,** February 5.—Pumping plant, for the Ministry of Public Works, Egypt. The Inspecting Engineer, Egyptian and Sudan Governments, Queen Anne's Chambers, Westminster, S.W.1. (Fee, 10s.)

**Santiago, Chile,** December 28.—Cranes, for the Chilian State Railway. The Department of Overseas Trade.

**Sydney, N.S.W.,** February 11.—One 5-ton electrically-operated overhead travelling bridge crane, for the Sydney Harbour Trust Commissioners. The Department of Overseas Trade.

**Toronto,** January 15.—One electrically-driven air compressor, with accessories, and one separator, also one centrifugal sludge pump, for the City of Toronto Department of Works. The Department of Overseas Trade.

## Obituary.

MR. A. E. GRANT, of British Insulated & Helsby Cables, Limited, died recently, aged 53.

MR. J. HUTTON, chairman and managing director of Alder & Mackay, Limited, gas meter manufacturers and brass founders, of New Grange Works, Stewart Terrace, Edinburgh, died on November 16.

MR. O. ROBSON, of Saltburn, died recently in his 71st year. After being associated for many years with James Watson & Company, he represented the pig-iron department of Bolckow, Vaughan & Company, Limited.

MR. J. P. DAVIES died at his residence, Bronycoed, Pontardawe, on December 9. He was a director of the Glanrhyd Tinplate Company, Limited, Pontardawe. The deceased gentleman, who was 58 years of age, had been in poor health for some years, and he was obliged to relinquish his position as managing director at the works.

THE WEST LANCASHIRE ELECTRICAL COMPANY, LIMITED, have removed to 4, Post Office Avenue, Southport.

# Institute of British Foundrymen.

## NEWCASTLE BRANCH.

At a meeting of the Branch, held on November 24, Mr. F. J. Cook (of Birmingham) read his Paper on "Blast Pressure and Volume for Cupola Working," Mr. James Smith presiding.

The PRESIDENT announced that it had been decided to hold the Annual Dinner at the time of the Convention Banquet, instead of in January, as stated in the syllabus. Committees were to be appointed next month for the purpose of carrying out the work of the Convention. He also announced that the Junior Section was holding a smoking concert on December 14.

In making sympathetic reference to the death of Dr. J. E. Stead, the PRESIDENT said that the late Dr. Stead was a very well-known man, and would be greatly missed all over the country. He was born on the Tyne and had worked practically the whole of his life on the Tyne and Tees. Dr. Stead was connected with many Institutions and Associations all over the country, and was very highly respected by everyone who knew him. He (the President) had heard Dr. Stead give three or four lectures and had received great benefit from them all.

Before calling upon the lecturer to read his Paper, the PRESIDENT said that Mr. Cook had been well known among them for a long time, and he believed that he had a warm place in his heart for Newcastle, because when he became President of the Institute of British Foundrymen, it was by his desire that the Convention came to Newcastle. It was a great success. Mr. Cook was also one of the founders of the Institute of British Foundrymen, and he felt sure that the younger men in particular would look up to a man like Mr. Cook, who had done so much for the Institute since it was founded.

Before commencing his lecture, MR. COOK thanked the President for his kind remarks, and said that he certainly had a warm place in his heart for Newcastle. It was true it had been his wish that the Convention should be held in Newcastle, and at that Convention he had spent one of his happiest times in connection with the Institute. He hoped, however, that they would do even better at the Convention next year.

The lecture which MR. COOK gave consisted primarily of the research on blast pressure and volume in cupola working contained in the Institute's Proceedings, 1912-13, augmented by some later work, including results of high-pressure fan tests, and results of tuyere obstruction due to improper proportions.

In apologising for reading an old Paper, he said that he had been requested to do so in the hope that it would arouse a good discussion. He wished to point out that it was a research which had been done a number of years ago, and since then a lot of thought had been put into the cupola. When the Paper was originally given, it contained much new matter, but it was too novel to arouse discussion.

### DISCUSSION.

MR. C. GRESTY said he concluded from what the lecturer had said about the Pitot tube that he more or less condemned it, because of the inaccuracy of the reading, but he would like to know if the lecturer did not think that this difficulty would be overcome if the manometer gauge was inclined.

Also, in the arrangement of the Venturi tube, what length of straight piping did the lecturer consider was essential? In most cupolas the problem was to keep away from bends which were well known to send the air currents astray.

Speaking of general cupola practice, he asked what effect the sizes of the charges had upon the cupola working, and if small charges were better than large ones.

In reply to the first question the LECTURER said that he did not condemn the use of the Pitot tube, although many people seemed to think that he did. As a matter of fact, he would have installed one, but in carrying out a research such as they were doing, they wanted something more accurate for regular work.

With regard to straight piping, that was essential, otherwise there would be a surging of air, and the results would be inaccurate. They had about 20 to 30 ft. between the Venturi tube and the outlet of blower.

With reference to the sizes of charges for cupola working, he said that depended very largely upon the size of cupola, but close-packing was essential, otherwise there would be a considerable leakage of air and consequently a low output. With a 10-ton cupola, they generally used 10-cwt. charges.

### Blast Measuring Instruments.

Further to the question of Pitot tubes, MR. R. O. PATTERSON said that the trouble they found was that the dust and fumes corroded the brass work of the tubes. After the tubes had been in the works for about a week, they had to be cleaned every two days, until finally they were discarded altogether. He would like to find something more serviceable. They used a Wilson blast recorder, which was a fairly satisfactory instrument, but at the same time quite an empirical piece of mechanism. They were not quite satisfied with that instrument, because they did not know for certain that the readings were correct. THE LECTURER agreed that the Pitot tube was a the dips in pressure due to tuyere poking. Did the lecturer believe in tuyere poking? In runs lasting 8½ hours, with a very few exceptions, they had no trouble with the tuyeres, and they worked with a blower which was giving them 24 to 26 in. water gauge on a cupola 56 in. dia., and obtained a correct volume of air.

THE LECTURER agreed that the Pitot tube was a very delicate instrument to use, because the atmosphere was both moist and dirty, but, however, they were quite easy to take out and clean. He thought that the Wilson recorder was rather a costly instrument, but there were no instruments giving direct readings which were correct. The amount of oxygen in the air varied from time to time, which accounted for the working of the cupola being better on one day than on another. Very often, when the results varied, it was thought that the cupola man was doing something he should not be doing, but the difference was simply due to the air conditions under which he was working. The Wilson instrument simply gave the volume of air going in, and was no true record, and the output varied according to the conditions of air.

The poking of tuyeres was one of the habits of the cupola man. He (the lecturer) thought that if the tuyeres were shut up for a minute or so, it was more satisfactory than poking.

### Fans, Blowers and Obstructions.

MR. W. J. PAULIN said that, because of the formulæ, Mr. Cook's lecture was rather difficult to follow. In answer to one of the questions, the lecturer had referred to the fact that there was no need to poke the tuyeres when choked up, and that it was necessary merely to close them for a minute or so. The obstruction, therefore, was removed by taking away the blast. Further on, the lecturer mentioned that the fan was not so useful as the blower, because a greater pressure could be obtained from the blower to remove an obstruction. Surely the one statement rather contradicted the other? In the one case, the blast removed the obstruction, whilst in the other case it actually created the obstruction. Was it not more often caused by increase of blast pressure raising the height of the melting zone than from any other cause?

The lecturer had mentioned that he used a pipe, measuring about 20 to 30 ft. from the Venturi tube to outlet of blower, but that seemed a very long pipe. They always put the fan as near to the cupola as possible, and did the lecturer not think that the slight increase of temperature derived from it might not help the melting? In a certain type of cupola made in Germany the air was passed through the hot space, and in that manner the output was increased enormously. He would like to know whether the long pipe had anything to

do with the decrease in output per unit of coke used.

THE LECTURER said it was quite true that his Paper contained a good deal of formulæ—anything to do with measurement of compressed air in quantity must necessarily contain formulæ. In speaking about the advantage of the blower over the fan for removing obstructions, he was speaking with reference to small particles, and not with reference to obstructions such as coal and slag.

The speaker was quite right about high pressure raising the melting zone, and he thought that that was a very important question. The lower the melting zone was, the smaller the amounts of carbon and impurities which were taken up, and the higher the tensile or physical properties of the metal.

He agreed with Mr. Paulin that the higher the blast pressure the higher the melting zone, and thought that bridging over was due to the more serious question of slag accumulations at the entrance to the tuyeres.

With reference to long piping, that was simply a question of position of blower to cupola. By heating the blast, one got a larger output and quicker melting, which was more economical from the coke point of view.

MR. J. H. COOPER asked if the lecturer could explain the cause of frothy slag which very often occurred in cupolas, because the slag seemed to be frothy for no apparent reason.

In reply, the lecturer said he thought that most people who had to deal with the cupola had experienced frothy slags. He was of the opinion that they were due to excessive oxidation in the cupola, and where the melting zone was too high for the level of the bed.

### Cupola and Defective Castings.

MR. R. WALLIS said he had once heard a man say that there were as many, if not more, bad castings made in the cupola than in any other part of the foundry.

He congratulated Mr. Cook on bringing his coke down to 7½ per cent., but would like his opinion as to the effect of greater amounts of coke.

With reference to the question of tuyeres in cupolas, he would like the lecturer's opinion of one row of tuyeres *versus* two. In the case of two rows, what should be the height of the second above the first? With regard to ratio of tuyere area to that of melting zone, what would be the effect of increasing the area of the tuyeres to a greater extent, say by one-third.

The lecturer did not say whether the sides of his cupola were parallel all the way down or contracted so as to bring the air into the centre. If they were contracted, what was the proportion of the contracted part to the parallel part? He thought that if contraction was resorted to, it should not be carried very high, or the melting zone would be higher than the coke bed, which would cause oxidation. With the high price of coke to-day, the question of economical melting was a very important one.

THE LECTURER agreed with Mr. Wallis with regard to the question of bad castings made in the cupola. He thought that, if, when oxidised, iron could be identified, it would lead to better castings, because he was confident that many bad castings were due to oxides in the iron.

With regard to the percentage of coke, it was much better to use too much than too little, as the former would merely result in softer iron, whereas the latter would probably give bad castings. He was not in favour of two rows of tuyeres when one row would give the necessary area and proper distribution of air. If the tuyere area was increased, the pressure was reduced, and consequently softer iron was obtained.

He was not in favour of contraction in cupolas up to a certain size, and would rather keep them parallel and not risk bridging over.

MR. M. E. GALLON said he thought that Mr. Cook had done more for the cupola than any other man in England. He understood the lecturer to say it was better to have pressure than volume. It appeared that he got pressure without volume, and he (Mr. Gallon) would like that point explaining. The lecturer had said that he got the same melting ratio in the smaller cupola as in the larger one, but what about the expenditure of coke in both; was the ratio equal there?

THE LECTURER replied that he did not say it was better to have pressure than volume, the object of his Paper being to show that one must have pressure and volume. The pressure must be varied according to the work in hand. If very soft iron was required, one must have a higher ratio, but for high-class work smaller tuyeres were necessary.

Regarding the question of the ratio of the melting efficiency, he had found it to be the same in both cupolas. Also in each cupola the same amount of coke per ton of metal was used.

### Increase of Sulphur on Remelting.

MR. H. J. YOUNG said it should be taken into consideration that it was possible for two scientific workers to get entirely different results owing to their working under different conditions.

One must recollect that there was a great deal of difference between a fan and a blower. Suppose, for instance, one has a cupola, with a fan and pressure gauge; then directly melting starts, and the cupola charge begins to settle, the pressure will rise. Always at the middle of the blow the pressure would be greater than at the beginning. Therefore, if pressure made metal hard, as Mr. Cook stated, then the iron in the middle of a blow should be harder than that at the start, which was not the case so far as he (Mr. Young) knew. The effect of pressure of blast upon the iron depended upon the composition of the iron, and he could not accept Mr. Cook's statement as applying to any other conditions than those of Mr. Cook's experiments.

The lecturer had not mentioned anything about composition of waste gases. All first-class engineers controlled furnace combustion by a knowledge of the analysis of the waste gases, and he would like to know why the cupola furnace could not be so controlled.

He would also like to know whether the sulphur-content always went up in cupola melting, or if it sometimes goes down, and did it depend upon blast pressure and for volume in any way? If the volume is controlled, so must the pressure be affected when a fan is used; equally, if the pressure was controlled, then the volume is affected. He would like to ask what the lecturer would do when using a fan, because the control of a fan was quite different, and gave different results from a blower. Would Mr. Cook control the pressure or the volume, and what would be the result of doing either in his opinion?

THE LECTURER agred with Mr. Young that different conditions gave different results. The chart he had shown showed that the pressure could be kept very regular, the trouble being that one might have a maximum of pressure, but the fan gave a minimum amount of pressure, and that might easily account for the difference in results under contracting conditions. In the other case there was pressure and no volume. He recommended a box on the outlet with the shutter open or closed, according to the volume required. With regard to pressure making the metal hard, he said that his first trouble was due to the question of pressure. They formerly used a fan, but had it changed for a blower. He had found that, if cylinders were cast at night, when the shops were working overtime and using electricity, the pressure was too small and the castings were soft, but if they were cast very late, when the shops were all closed, they got too much pressure, which resulted in hard cylinders. He solved the problem, however, by installing a pressure gauge for the purpose of controlling the pressure.

MR. YOUNG asked if there was no alteration in volume under those circumstances.

THE LECTURER replied that there would be an alteration in volume. With regard to waste gases, in order to have made the research complete, the waste gases from the cupola should have been analysed, but, unfortunately, they had no means of doing the analyses. He quite realised that if that work could have been done, it would have greatly added to the value of his Paper.

With reference to sulphur, he thought there could be no doubt about the fact that at the start

the sulphur did go up when using cupolas without receivers, but he agreed that some of the sulphur would probably be extracted afterwards, and would show a lower figure than at the beginning of the melt.

As regards the fan *versus* the blower, the lecturer said that he preferred a blower, partly because it was much simpler to control.

### Vote of Thanks.

MR. J. H. WATSON said it gave him great pleasure to propose a hearty vote of thanks to Mr. Cook for his very instructive and enjoyable lecture, and MR. E. WOOD seconded this proposal, which was carried unanimously.

In thanking the members for their kind appreciation, MR. COOK said that he had read the Paper in the hopes that it would arouse a good discussion, and, if the audience was satisfied, he was gratified.

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## BURNLEY SECTION.

## Discussion on Mr. F. W. Rowe's Paper on "The Founding of Admiralty Gunmetal and Allied Alloys."*

MR. JACKSON asked what measures should be taken to get homogeneity of the metal. By that he meant how to ensure that in a number of small castings on a plate the first casting had the same composition as the last.

MR. ROWE replied that if due care was taken and the pot well stirred up immediately before casting he did not think it likely that there would be any appreciable variation between the top and bottom of a casting or between the first and last casting in a plate box. Sometimes trouble did occur when the percentage of lead was high, say 8 or 9 per cent. This could be avoided by well stirring the pot immediately prior to pouring and casting at the correct temperature.

MR. JACKSON said that to stir up the pot when it was in the fire was an unpleasant job. He had seen the practice of stirring in the fire adopted but he did not like it.

MR. ROWE: It is not necessary to stir in the fire.

MR. JACKSON: When the pot is drawn it requires a great deal of stirring to get a thorough mixing unless some special methods are adopted.

MR. ROWE said he did not think he could agree with that, as he had had as many as 20 or 30 castings on a plate of ordinary bronze (5 tin, 5 zinc, and 5 per cent. lead), and there had never been any appreciable variation between the first and the last. With a heavy percentage of lead, if it is cast too hot and the metal is molten a considerable time, it allows time for the lead to segregate.

### The Utility of Fluxes.

MR. PELL asked what flux Mr. Rowe used and the quantity per cwt.

MR. ROWE said in the foundry he was connected with they always melted only under charcoal; he thought that was necessary, but they did not use any flux. Some people adhered to the practice of fluxing, but there were very few alloys where it was required and these special cases. Many patent fluxes had been placed on the market, but his experience was that they did not make any appreciable difference.

MR. PELL said in asking the question he had in mind the melting of non-ferrous alloys, whether the fluxes were worth buying for that purpose or not.

MR. ROWE: There are one or two special alloys —aluminium alloys for instance—where they are of considerable value, but for the ordinary run of gun metal or phosphor bronze they are of no use at all.

Replying to Mr. Derbyshire, MR. ROWE said in making Admiralty gun metal there was a slight advantage in adding zinc before tin. The theoretical reason was that although melted under charcoal, a certain amount of oxide was generally present. If the tin was added first the tin would deoxidise the copper. Tin oxide was very sluggish and did not rise to the top to be skimmed off nearly as rapidly as zinc. There was just a fear if the tin was added first and it did sometimes happen—that crystals of tin oxide would become embedded in the metal, and tin oxide was the worst possible constituent one could have in a bronze casting. It was about twice as hard as the hardest crystals in a hardened tool steel, and in a bearing would score any journal.

### Phosphor Bronze Mixtures.

MR. GLOVER asked the author to give an approximate mixture for phosphor bronze for general use, as it was not often mentioned in the text books.

MR. ROWE: The most general mixture for phosphor bronze is 90 copper and 10 per cent. phosphor tin, which gives a metal the composition of which approximately is copper, 90; tin, 9.5; and phosphorus, 0.5 per cent.

MR. J. BEECROFT: Is there any advantage in using phosphor-tin instead of phosphorus in making a heavy bearing?

MR. ROWE said if stick phosphorus was used there was a risk of a pyrotechnic display and injury to the men, and there was no advantage in using it when it was just as easy to get phosphor-copper or phosphor-tin.

MR. BEECROFT: If one makes a phosphor-bronze casting, phosphorising it oneself, and in a few years that casting is returned and remelted, is the phosphor bronze the same?

MR. ROWE explained that there would be a slight loss of phosphorus through oxidation. Supposing the casting had contained 0.5 per cent. phosphorus, the loss would be about 0.1 per cent. phosphorus.

MR. BEECROFT: It has ceased to be a genuine phosphor bronze.

MR. ROWE: If a little phosphorus is added to make up that loss on oxidation exactly the same thing is produced. In fact, if virgin metal is originally used and is then remelted, it will give a sounder metal. In further explanation Mr. Rowe said if stick phosphorus was damp when put in the pot, or if not put well under the metal, it would splash and probably burn the operator's hand, and a phosphorus burn was the hardest burn to cure. There was no necessity to take such a risk when manufacturers were making tons of phosphor-tin every day, much better and more cheaply than the foundryman could do it himself, and quite the same results could be got much more easily than with phosphorus.

MR. BEECROFT said he failed to see that there was any grave risk in using phosphorus.

MR. ROWE said he had known people burned by it and he thought the risk was considerable. It ignited at 40 deg. C. and was liable to burst into sudden flames.

### Types of Furnaces.

THE CHAIRMAN asked what was the best method of melting?

MR. ROWE said there was nothing better than the ordinary pit-fire furnace for small parts such as were generally made. In 100- to 200-lb. pit-fire furnaces one obtained just as good melting as with any of the patent furnaces. If it was properly built and properly charged, the results were quite as good and economical as those got from a tilting crucible or the like. The coke consumption might be a little higher, but there were compensations for that. With care one could get 60 to 80 heats out of an ordinary crucible in a pit-fire furnace.

MR. PELL: Which is the more economical—the square pit fire or the round pit fire?

MR. ROWE: I think the round pit fire is more economical than the square pit fire, but there is not a great deal in it. There is more in the setting of the fire bars and the arrangement of the blast than whether it is round or square.

MR. PELL remarked that the reason he asked the question was that in the square pit fire the corners had to be filled up, and in the round pit fire the supply of coke was equal all round.

MR. ROWE said Admiralty gun metal was not a really good bearing metal, and the trend of modern practice was not to use it for that purpose. For heavy loads on wide bearing surfaces the most commonly used bearing metal was leaded phosphor-bronze, *i.e.*, an ordinary phosphor-bronze with about 82 copper, 8 lead, 10 tin, and 0.5 per cent. phosphorus.

* This Paper was printed in our last issue.

### Sands for Non-Porous.

MR. DERBYSHIRE asked whether he would get the same benefit as when casting green sand if he used dry sand, letting it go cold?

MR. ROWE said it was the moisture in the green sand which robbed the metal of its heat, and cold dry-sand moulds had not the same chilling effect as green sand.

THE CHAIRMAN: Have you any particular sand for this class of work, such as Mansfield sand or yellow sand?

MR. ROWE said it all depended on the class of work that was being made. For practically all brassfounding one could use a local sand. But there were some castings with which it would not be safe to use a local sand.

MR. HOGG: Is there any special method of annealing Admiralty gun-metal castings or do you just put them in the fire?

MR. ROWE said the temperature of the casting must be even and under control. With a gas-fired muffle furnace one could control the temperature very closely between 600 and 700.

MR. HOGG: Does the openness of the sand, or the closeness of it, have any effect upon the casting? Suppose one is casting anything in brass. Can one use Mansfield sand or a very close yellow sand? Would that be the cause of small blow-holes forming?

MR. ROWE said clayey sand like Mansfield tended to produce blow-holes on the surface and was useless for pressure work.

MR. HOGG: Even if the mould is dry?

MR. ROWE: Yes, very often even if the mould is quite dry.

A vote of thanks to Mr. Rowe was moved by Mr. Hogg, seconded by Mr. Jackson, and passed unanimously.

## Personal.

SIR EUSTACE TENNYSON D'EYNCOURT will retire at the end of the year from the position of Director of Naval Construction at the Admiralty. He is returning to Sir W. G. Armstrong, Whitworth & Company, Limited, Elswick.

MR. H. J. YOUNG, F.I.C., of the North Eastern Marine Engineering Company, Limited, is to represent the North-East Coast Institution of Engineers and Shipbuilders on the British Engineering Standards Association's Committee on Cast Iron.

MR. ROBERT SMEATON has been appointed general manager of Palmer's Swansea Dry Dock Company, Limited. Mr. Smeaton has been with the Palmer Company for a number of years as manager of their Jarrow and Hebburn repairing establishments.

MR. R. H. DAVIS, general manager of the Firth-Sterling Steel Company, of Pittsburgh, has returned to the United States from a trip to Sheffield. He was accompanied by Messrs. J. W. Fawcett and E. Holmstrom, of Thos. Firth & Sons, Limited, who are on a business visit to that country.

SIR WALTER RUNCIMAN has resigned from the chairmanship of the Blyth Shipbuilding & Dry Docks Company, Limited, he having only taken up the position temporarily last year. He advises the directors to elect Mr. R. M. Sutton to the chairmanship. Sir Walter remains a director of the company.

MR. G. A. C. PETTITT has been elected a director of J. & E. Wright, Limited, in place of the late Mr. A. H. Gibson. Mr. G. Turner has resigned his position as managing director, but remains on the board, and Mr. W. H. Turner and Mr. T. A. Taylor have been elected joint managing directors.

### Will.

NUTTALL, J. N., head of the firm of Bentley & Jackson, Lodge Bank Works, Lord Street, Bury ..... £11,970

THE TRAMWAYS COMMITTEE of the Corporation of Glasgow last week considered tenders by British and American firms for contracts to supply rails for special track work. The Sub-Committee on Works and Stores announced the receipt of four offers:—The United States Steel Products Company, Limited, £8,568; Hadfields, Limited, £9,764; Edgar Allen & Company, Limited, £9,867; and the Titan Trackwork Company, Limited, £10,031. The sub-committee recommended that the contract be divided between the four tenderers. This advice has been rejected by the committee, however, and the tender of the American firm has been accepted.

## Correspondence.

*[We accept no responsibility for the statements made or the opinions expressed by our correspondents.]*

### The Decline of Semi-Steel.

*To the Editor of* THE FOUNDRY TRADE JOURNAL.

SIR,—In the recent discussion under this heading there appears the underlying suggestion that semi-steel has fallen from grace and has been replaced by special pig-irons.

It may be that a relatively smaller production of semi-steel obtains to-day, but I cannot agree that it is caused—at any rate in the case of a number of foundries of which I have intimate knowledge—by "trouble being experienced and not overcome," or even to the "increased reliability of special pig-irons now on the market."

It will, I think, be conceded that in order to obtain the maximum degree of success in semi-steel working it is desirable to work in large amounts, and to operate a separate cupola for it or to be able to run as many charges as possible when melting has to be effected in the same furnace as other material, owing to the impossibility of completely separating individual charges and the fact that steel melts in advance of the pig-iron and passes into preceding charges.

The present unfortunate condition of trade does not always permit of these desirable arrangements, and in many cases explains the relatively small output of semi-steel, the founders preferring to use the better grade pig-irons for the smaller melts of high-strength castings and use only one furnace. The suggestion made by "Cupola" that semi-steel is losing ground because an apparently wider demand exists for certain so-called special pig-irons is scarcely warranted. It must be remembered that for some time the better grades of foundry pig-iron were somewhat scarce owing to the reduced number of blast furnaces in operation, and as the special irons were obtainable at considerable reduction in price, many founders bought these for mixing with commoner material. Further, as certain merchants class as "special" a pig-iron containing 1.5-2.0 per cent. Mn, which many founders use for semi-steel production, the increased sale of special iron might be evidence not of the decline but of the advance of semi-steel.

Mr. Wheeler suggests that the conditions for successful melting of semi-steel are greatly different from those required for melting special pig-irons. I cannot agree with him. The essential conditions for good work with semi-steel are precisely the same as for good work with pig-iron and scrap, viz., good and efficient cupola practice, which is to be obtained by careful attention to the design and operation of the cupola, with especial regard to the proportioning and admitting the air supply, conditions which should obtain in every foundry, if the British foundry industry is to hold its own. The day of haphazard, inefficient cupola working is past, and where difficulty is experienced in melting on account of poor cupola practice, surely the remedy must be to use modern methods in the melting department. All materials, especially the air, must be weighed or measured, and charges made proportionate to the furnace.

If this be done there can be no room for doubting the statement, "Semi-steel has sufficiently established itself as a reliable, easily made material."

I know of foundries making marine and engine castings of the highest quality where nothing but semi-steel is melted, and where special pig-irons never enter.—Yours, etc.,

A. CAMPION.

Glasgow,
December 11, 1923.

THE BOARD OF the British Hydraulic Foundry Company, Limited, report that since the synopsis of the chairman's remarks made at the meeting on October 26 last was circulated, intimation has been received from some of those who then voted against the proposed liquidation, stating that in view of the explanations given they are now prepared to agree to voluntary liquidation. The shareholders met again last Friday, when a fresh proposal for voluntary liquidation was submitted.

# Design of Large Foundry Ladles.

BY K. MORRISON.

In this article a few of the more important points concerning the design of foundry ladles of the larger sizes will be considered and special attention paid to the particular problem of geared ladles.

Firstly, the bowl of the ladle is subjected to a combination of stresses, four to be exact, each of which has its effect on the general features of the whole design. These stresses may be enumerated as under:—

(1) A bursting pressure on the shell and end due to the weight of the metal.

(2) A bending of the whole ladle between the trunnions.

(3) A torque of the whole ladle due to out of balance effect of the metal when pouring.

(4) A collapsing pressure through the line of the trunnions tending to make the bowl oval, the centre line of the trunnions being on the shorter axis, and caused by the taper of the bowl.

The first of these is a directly calculable stress, and may easily be allowed for. It fixes the minimum thickness of the shell and bottoms, and also decides the riveting. Practical conditions, however, usually decide these questions at a much larger figure than is given by this calculation.

The second stress is rather more difficult. The whole ladle may be considered as a beam supported at the ends and loaded in the centre, the load per foot run increasing from zero at the supports to a maximum at the centre, and thence decreasing to zero. Now, when the ladle is vertical this load and its effects are simple and calculable. When, however, the ladle is tilted, the whole problem is altered and the moment of resistance to bending becomes a calculation, which none but an expert mathematician would attempt. What the amount of this stress is it is difficult to say, but the effect of it is to bend the trunnions and so impair their alignment. This bending is noticeable when a ladle is thoroughly hot, in which condition the true elastic limit is much reduced, and the bending then takes place. Its effect can be minimised by making the bearings as short as possible and allowing ample top and bottom clearance in them. Some manufacturers fit outer bearings, but these are only useful when least required, *e.g.*, when the ladle is vertical. It is during the process of tilting that they would be of service, and at this time these strap bearings are of no service.

### How Splashes are Caused.

Thirdly, the torque of the whole ladle, a point of purely academic interest, but worth mentioning. If, when tilting, the centre of gravity of the ladle and the metal in it moves off the vertical centre line through the trunnions, then there is a tendency for the ladle to move so that the centre of gravity will lie on this vertical centre line. If such a position for the trunnion could be found that the centre of gravity would always lie on the vertical centre line of the ladle, then a ladle would be perfectly balanced. Unfortunately, this is a mathematical impossibility, and the most the ladle manufacturer can do is to minimise this as far as possible by experiment—the calculation of it being a labour that few would care to attempt. In practice it is found that the out of balance effort of a ladle varies through the 90 deg. of pouring, and a position for the trunnion can be obtained where the torque is reduced to a minimum. In this position it will be found that the ladle when upright and full is in unstable balance and becomes overbalanced on the slightest tilt. This condition of overbalancing continues until the centre line of the ladle is tilted through an angle of about 30 deg., when the ladle again becomes in a position of unstable balance. Up to this point the gearing is doing negative work, *i.e.*, is preventing the ladle from overturning. From about 30 deg. of tilt to about 60 deg. the gearing is acting against the ladle, which is now underbalanced and tending to right itself. From 60 deg. onward the first condition holds, and the ladle tends to overbalance. The effect of this uneven torque is often felt by the ladle splashing at these points if the gearing is slack. At the first, when the ladle starts to pour, the effect is for the lip to drop; in the second case to rise, and the third again to drop. The correct method of overcoming this is by properly fitting gears and not by raising the trunnion on the ladle to such an extent that the torque always becomes positive. It must be noted that these remarks apply to the ladle when in the process of emptying from full. A ladle empty or turning from vertical partially empty is a totally different problem.

### The Influence of Taper.

The fourth and last stress in ladles is perhaps the most serious. It is due to the taper of the ladle bowl. If anyone cares to make up a ladle in drawing paper with a fairly large taper in the diameter, pass a knitting needle through it to represent the trunnion, and fill it with water, he will find that the sides at the top will come in to meet each other. If the pull of the arms acted in a line parallel to the side of the ladle, then this collapsing pressure would cease to exist, and this fact indicates the obvious solution to the difficulty, *i.e.*, to make the taper of the ladle as small as practical conditions will permit. The bowl should be made as stiff as possible where cut away for the lips, and the lips themselves made heavy for the double purpose of resisting burning as well as to compensate for the metal removed to allow of their being fitted.

Finally, it should be remembered that ordinary calculations of stresses are not permissible since the allowable stress must be greatly reduced owing to the weakness of steel at the temperature of a ladle bowl. It is also probable that the steel itself deteriorates through time.

### Ladle Arm Considerations.

The arms of the ladle also introduce some interesting features. The plain side arm is in direct tension only. The gear side arm has a more complicated stress. Firstly, it has tension due to the load. Secondly, it has a sideways bending moment due to the thrust of the gearing, and, thirdly, it has a torque due to the overhang of the gearing. The first stress is impossible to take up, but the second may be reduced in two ways: (1) by using a highly efficient gear, and (2) by reducing the turning effort to its minimum as discussed previously. The third may be reduced in three ways, two of which are enumerated above and the third of which is to reduce the overhang of the gears as much as possible. Lastly, it should be noted that the arms do not work at normal temperature, so that they must be amply strong for the direct load.

The bridge has principally simple bending moment, to which must be added a slight torque due to the out-of-balance effort of the ladle. Here again a large reserve of strength is essential, since the temperature of the bridge may rise to an astoundingly high figure. The shackles for the crane should be broad and deep enough to admit a crane hook without the necessity of guiding by hand.

### Gear-Box Design.

The design of the gear box can exercise the brain of the manufacturer to some extent. Some of the general features have been discussed under the headings of the arms. The principal points to be aimed at, are: (1) High mechanical efficiency; (2) small overhang; (3) non-reversibility; and (4) total protection.

From the point of view of strength, it should be so designed that five men, hauling on the handle provided for tilting, cannot, when the ladle is locked, break any of the gears. In order to apply this test one has to provide a special handle. The reduction provided in the gearing should just give the lip of the ladle about 6 in. travel for every revolution of the turning handle. Most gears have too great a ratio, and fail in this respect. At this reduction one man should easily tip the largest ladles. If the trunnions are correctly set so that the turning effort reverses during pouring, there is the possibility of splash if the backlash on the gearing is too great. The total backlash should not amount to more than 1½ in. of lip travel when cold.

XUM

There is yet scope for much ingenuity in developing the transport of hot iron to moulds, and the writer does not consider that the ladle, as at present made, represents the end of the problem. The engineer is handicapped by lack of knowledge of the cost of handling metal, and the foundryman argues that ladles in their present form have worked for years, and therefore are still satisfactory. It is, however, to the advantage of every foundry to carry their metal easily, to pour it smoothly and with perfect control from as small a height as possible, to prevent, from this cause, sand and blow holes in the castings.

## Open-Hearth Furnace Regenerators.*

By FRED B. QUIGLEY.

In the early days chequer chambers were built as part of the foundation of the furnace, which was a poor design. There was always the chance of steel breaking through the bottom of the furnace and filling up the chequers. With the regenerators set to one side of the foundation of the furnace proper, repairs can be made to either without disturbing the other. The design for modern furnaces uses vertical chequer chambers for both gas and air. These have numerous advantages. The hot air rises naturally in the vertical chamber, due to the decreased density caused by the increase in temperature of the air as it rises from the cooler chequers in the bottom rows to the hotter ones on top. This produces a positive pressure to the air, which forces it through the port and helps to control the projection of the flame on the bath. This pressure is not so necessary with the gas, because it comes from the producers under pressure.

The modern flue arrangement for regenerators provides for the chequer chambers to be built on an angle pointing toward each other, so that the outgoing flues from the chequer chambers will be approximately radial to the stack from both chambers, which will also give the easiest flow-line and the shortest route for the gases to the stack or waste-heat boilers.

The Carnegie Steel Company's open-hearth committee has decided upon the following as the minimum requirements in regard to size of regenerators for a 100-ton producer-gas furnace :—

*Air Chamber.*—30 ft. × 12 ft. × 20 ft. deep, 68 cub. ft. per ton of steel (entire chamber); 150 sq. ft. of heating surface per ton of steel.

*Gas Chamber.*—30 ft. × 8 ft. × 20 ft. deep, 46 cub. ft. per ton of steel (entire chamber); 100 sq. ft. of heating surface per ton of steel.

The air chamber should be larger than the gas chamber, because the air comes to its chamber cold, while the gas is at a considerable temperature before it gets to the chequer chamber, and it requires more than one cubic foot of air to burn properly one cubic foot of producer gas. Theoretically the ratio is about 1.3 to 1. To this must be added a slight excess of air. In actual practice the ratio usually runs 1.5 to 1.

In the past, very little attention has been paid to the heat insulation of the chequer chambers and the infiltration of air due to the stack draft. As has been shown by carefully-made heat balances of open-hearth furnaces, there is a large proportion of excess heat in the waste gases entering the chequer chambers which cannot possibly be recovered in preheating the air and gas to the furnace. In the cases where the waste gases are allowed to pass directly to the stack, the heat insulation of the chequer chambers and the flues and the loss in the valves and the infiltration of air are not important, as it makes small difference to the working of the furnace whether the heat is lost by radiation from the chequer chambers or in the stack.

However, with the increasing use of waste-heat boilers for recovering the surplus heat in the waste gases, the insulation of the chequer chambers and the prevention of infiltration of air become extremely important, and it has been proved in practice that a much larger amount of steam is produced in the waste-heat boilers if the chequer chambers are properly heat-insulated and if care is taken to close up openings which allow air to be mixed with the waste gases before entering the waste-heat boilers. One of the modern methods of insulating chequer chambers is to use boiler plate as a casing on the outside surface, and between this and the brick is placed some heat-insulating material. One plant has had the walls and roof of the chequer chambers of two furnaces insulated for over a year with no harmful results to the roof of the chambers.

Both the Papers by Clements (British) Iron and Steel Institute, May, 1922, and the one by Kinney and McDermott show by their figures that the gas regenerators in the furnaces they ran their tests in do little work in preheating. This brings up again the possibility of doing away with the gas chequer and insulating the gas flue from the producers to the furnace. If this were possible, there might be opportunity for a better proportioning of the air chamber, having the additional room occupied by the gas chamber. In such a case, there would be an even greater excess of waste heat available, which could be utilised to advantage in waste-heat boilers.

Insulation of chequer chambers has proved advisable, and especially so in the case of waste-heat boilers. It is also possible to gain thermal efficiency by the insulation of the passageway (fantail) from the chequer chambers to the slag pockets, and this might be extended to the slag pockets as well.

* Abstract of Paper read before the American Iron and Steel Institute, New York.

## Diffusion of Phosphorus in Iron.

At a meeting of the South Staffordshire Iron and Steel Institute, Mr. F. J. Cook presiding, held last Friday, MR. NORMAN C. MARPLES read a Paper on "The Diffusion of Phosphorus in Iron and Iron-Carbon Alloys." Summarising the results of his researches, the author states :—

(1) Phosphide of iron will only diffuse into pure iron when the latter is so heated as to be in the gamma condition.

(2) Phosphide of iron will diffuse into low and medium carbon steels when these latter are heated above their A3 or A3.2 points.

(3) In eutectoid steels, diffusion of phosphide does not occur on heating just above tme A3.21 point, nor does the phosphide diffuse at temperatures as high as 960 deg. C. in this material. The absence of diffusion is directly attributable to the saturation of the ferrite by the carbon.

(4) The rate of diffusion of phosphide of iron is greater into pure iron than into steel containing 0.5 per cent. carbon.

(5) The presence of 1 per cent. phosphorus in solution in iron (free from carbon) raises the alpha to gamma change to above 1,000 deg. C., thereby elevating the diffusion temperature of the phosphide; this elevation of the alpha-gamma change is the reason for the persistence of the cored structure of cast phosphoric iron after annealings at temperatures just within the normal gamma range, but below the elevated gamma range; the diffusion of phosphide into pure iron from the phosphoric iron takes place immediately the A3 point of the latter is passed.

(6) When steels containing 0.5 per cent. carbon and 0.2 per cent. phosphorus are slowly cooled from elevated temperatures, there is a "zone" of low phosphorus ferrite, around the pearlite grains, which is formed by coalescence of the pearlite at temperatures at which the phosphorus is no longer mobile; this view is supported by the complete absence of such a "zone" around the troostite grains when a similar steel is quenched from above its A3.2 range.

(7) That it is probable that the formation of this "zone" indicates why it is that a phosphoric steel exhibits an intra-crystalline fracture since the ferrite in the vicinity of the pearlite grains will be less brittle than the main mass of the ferrite.

(8) That micro-ghost lines can occur in carbon free iron due to the presence of segregated phosphide; micro-ghost lines occurring in this way are not detected by picric-acid etching, and are only revealed after etching with a cupric reagent.

# IRON AND STEEL MARKETS.

## Pig-iron.

**MIDDLESBROUGH.**—Markets on Tees-side already foreshadow the near approach of the Christmas holidays, and business, as is usual at this season, is beginning to slacken down as far as buying for present requirements is affected. It is, however, reassuring to report that the prospects of trade are distinctly brighter for the New Year, the volume of business being booked on forward account for home consumption showing an appreciable improvement, and completely absorbing the present output capacity of furnaces in the Cleveland area. Export business, on the other hand, is exceedingly disappointing so far as the returns for the current month are available, being only less than half the tonnage shipped in the corresponding period of November. Meantime, prices are firmly maintained, though without actual change in quotations, which remain as last reported, with No. 1 at 107s. 6d., No. 3 G.M.B. 100s., No. 4 foundry 99s., and No. 4 forge 98s. per ton.

The hematite position has more than recovered from the temporary lull recently reported, and is, in fact, stronger than ever. There is practically no prompt iron available, and the price of East Coast mixed numbers, both for prompt and the early weeks of next year, is firm at 102s. 6d. per ton, with a premium of 1s. per ton for the No. 1 quality. In the North-West area hematite values remain firm, with Bessemer mixed numbers at 115s. per ton delivered at Glasgow and Sheffield, and 120s. per ton delivered at Birmingham. Low-phosphorus iron is in fairly steady request.

**MANCHESTER.**—In this district the demand for foundry iron is quiet, with prices, however, remarkably firm. Sellers of Derbyshire foundry iron are quoting about 95s. and upwards per ton at the furnaces for No. 3, and this class of iron has been sold in Manchester at rather more than 103s. delivered, although at the same time one hears of sales as low as 102s. delivered. Sellers of Scotch iron say that the demand in the Manchester district of late has been rather better, but the price of this quality iron is relatively higher, and the lowest figure lately quoted for delivery of a good brand of No. 3 Scotch was 125s. per ton, delivered in Manchester.

**THE MIDLANDS.**—Smelters in this area mostly report a fairly steady inquiry, of which, however, the main proportion is confined to forge pig, foundry qualities continuing only in quiet demand, consequent upon the general slackness in that industry. Quotations are firm as follows:—Northamptonshire foundry, 93s. 6d.; Derbyshire foundry, 95s., all net f.o.t. furnaces.

**SCOTLAND.**—Business in the Glasgow iron market during the current week has been on a more restricted scale than of late, with very little buying anticipated until the turn of the year. Meanwhile, prices are firmly held at 107s. 6d. f.o.t. furnaces for No. 3 foundry Scotch. There is no business being done with the Falkirk founders, as they are all bought for some time ahead and are inclined to see more iron melted before making fresh purchases. No. 3 Middlesbrough is quoted to-day at 107s. at Grahamston, with No. 4 foundry 2s. per ton less.

## Steel.

The market for steel continues on fairly active lines, with manufacturers' order-books well filled for some time ahead, especially for semi-products, which of late have disclosed increasing strength. There is, however, some variation in the price of billets, which are much cheaper in Wales than in the Midlands and the North, while for tinplate and sheet bars there is some good business offering. Sales of tinplates during the past week have been heavy, and quotations remain firm at round 24s. 3d. per basis box. The overseas buying, except to China and Australia, has been good. India and the Far East and several of the Continental countries, including Germany, having been in the market. Official prices of ferro-manganese are unaltered for the time being, but business has improved considerably of late, and a return to the recent higher level is not improbable.

## Scrap.

The improved conditions in the scrap-metal trade previously reported continue to develop in most sections, notably in the demand for foundry material, although it is questionable whether this will take substantial shape until after the holidays are concluded. The prices for good foundry scrap, however, vary a good deal in different districts. In South Wales 92s. 6d. per ton is being paid for ordinary broken machinery metal, and in the North-East up to 97s. 6d. per ton, but in the very important Lancashire ironfoundry district it is not yet possible to obtain such prices. Lancashire cast scrap at 85s. and 87s. 6d. per ton is reported, and we suppose that the reason for this is the lack of work at the local foundries. There is still rather too much cast scrap offering in Lancashire, and some of the dealers seem to be rather weak holders. Scottish consumers of cast-iron scrap seem to be fairly well covered up to the end of the present month, but some are anxious to secure supplies for delivery early in the year. The pig-iron market is still strong, and, of course, this affects cast iron. Merchants are still averse to commit themselves for delivery ahead unless they have the material actually in view. Heavy machinery metal and scrap railway chairs run about 105s. to 107s. 6d. per ton, according to point of delivery, and ordinary heavy cast iron about 95s. to 97s. 6d. Light cast iron and furnace fire bars are at 80s. per ton.

## Metals.

**Copper.**—The position in the standard market during the past week has been somewhat irregular, but values, on the whole, have been remarkably steady, with few evidences of speculative operations as a disturbing element. Advices from the States report a slight improvement in export sales, but production at the mines has increased considerably, and surplus stocks, which already amount to a large tonnage, are increasing. In this country, although prevailing conditions are quiet, the tone is better than that across the Atlantic. Consumption is on quite a fair scale, while stocks in home consumers' hands are not large, and better business is anticipated with the advent of the New Year. Current quotations:—*Cash*: Thursday, £62 5s.; Friday, £62 2s. 6d.; Monday, £62 10s.; Tuesday, £62 7s. 6d.; Wednesday, £62. *Three Months*: Thursday, £62 17s. 6d.; Friday, £62 17s. 6d.; Monday, £63 5s.; Tuesday £63 2s. 6d.; Wednesday, £62 17s. 6d.

**Tin.**—An outstanding feature in this section of the metal markets last week was the check experienced in the upward trend of tin values, followed by a fluctuating tendency traceable mainly to aggressive selling on the part of speculative operators, but hardly justified by the strength of the statistical position.

Ricard & Freiwald's statistics for November are appended:—

MONTHLY SUPPLIES.—Shipments from Straits to U.K., 1,495 tons; shipments from Straits to America, 3,265 tons; shipments from Straits to Continent, 615 tons; shipment from Australia to Europe and America, 200 tons; supplies of Banca and/or Billiton tin, 800 tons; standard arrivals in U.K. and America, 1,750 tons; total, 8,125 tons.

MONTHLY DELIVERIES.—United Kingdom, 1,627 tons; Holland, 566 tons; America, 6,785 tons; Continent (except Holland), 622 tons; total, 9,600 tons.

Current quotations:—*Cash*: Thursday, £239 15s.; Friday, £236 7s. 6d.; Monday, £233 7s. 6d.; Tuesday, £234 5s.; Wednesday, £232 15s. *Three Months*: Thursday £240 17s. 6d.; Friday £237 12s. 6d.; Monday £234 12s. 6d.; Tuesday £236 5s.; Wednesday, £236 5s.

**Spelter.**—The demand for this metal remains fairly active, with values comparatively steady. Conditions on the Continent, though, on the whole, not showing any very material change, have perhaps been a trifle easier. The market in the United States remains steady, and the position there is relatively unchanged. Current quotations: — *Ordinary*: Thursday, £32 7s. 6d.; Friday, £32 8s. 9d.; Monday, £32 10s.; Tuesday, £32 11s. 3d.; Wednesday, £32 11s. 3d.

**Lead.**—The market for soft foreign pig continues firm and values remain fairly steady. The higher prices ruling have attracted more metal from the Continent, but all supplies are extremely well held, and buyers have been compelled to pay a premium for prompt metal. Current quotations:—*Soft foreign (prompt)*: Thursday, £31 15s.; Friday, £31 10s.; Monday, £31 10s.; Tuesday, £31 7s. 6d.; Wednesday, £30 15s.

## Gazette.

MR. E. B. BRITNELL, iron and steel merchant, Chester, has declared a first and final dividend of 3s. 3d. in the £.

MESSRS. R. E. COUCH and J. H. RADCLIFFE, engineers, etc., Finsbury Pavement House, London, E.C., trading under the name of Couch & Radcliffe, have dissolved partnership. Mr. R. E. Couch continues.

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## Company News.

**Ambrose Machines, Limited,** 116, Hope Street, Glasgow.—Capital £100 in 1s. shares.

**Pinchin, Johnson & Company, Limited.**—Preference dividend, 6½ per cent. per annum, less tax.

**Cement and Steel, Limited,** 147, Fenchurch Street, London, E.C.—Capital £1,000. Directors: C. A. Linforth and A. Rikby.

**G. D. Peters & Company, Limited.**—Dividend for quarter to December 31, 6 per cent. per annum, less tax, on preference shares.

**Lead Pipes, Limited.**—Capital £2,000 in £1 shares. Solicitor: F. C. Watkinson, Station Street Buildings, St. Peter's Street, Huddersfield.

**Atlas Steel Foundry & Engineering Company, Limited.**—Loss, £4,098, bringing up amount at debit of profit and loss to £13,896, which is carried forward.

**Parsons' Foreign Patents, Limited.**—Net profit, £6,907; brought forward, £427; dividend on ordinary, 4½ per cent. and 2s. 3d. per deferred share; carry forward, £3,525.

**W. A. Saxby & Company, Limited,** 3-5, Gayford Road, London, W.—Capital £1,000. Machinery merchants, etc. Directors: W. A. Saxby, E. R. Parsons and E. G. A. Williams.

**Edison Swan Electric Company, Limited.**—Profit, £71,162; redemption of debenture stock, £7,003; dividend, 7½ per cent. on ordinary; reserve, £30,000; carried forward, £19,304.

**Palmers Shipbuilding & Iron Company, Limited.**—Profit for two years, £88,554; debenture and loan interest, £159,083; debenture redemption funds, £39,034; brought forward, £34,346; debit balance, £75,217.

**North Lonsdale Iron & Steel Company, Limited.**—Depreciation of plant, £2,500; written off Parkside & Birks Mining Company, Limited, shares, £6,058; credit balance, £4,946; brought forward, £17,772; dividend, 2 per cent. (less tax); carried forward, £17,782.

**Rallings Engineering Works, Limited.**—Capital £4,000 in 2,625 7 per cent. cumulative preference shares of £1 and 11,000 ordinary shares of 2s. 6d. Directors: A. B. E. Cheeseman and E. H. W. Rallings, 94, Clarendon Road, London, S.W.15.

**Armstrong Whitworth Development Company, Limited.**—Profit, £69,489; brought forward, £16,674; dividends paid, 15 per cent., free of tax, on ordinary and 6 per cent. per annum on preference; final dividend on these shares at same rate for past half-year; carry forward, £12,399.

**Southern Foundries, Limited,** 185, Piccadilly, London, W.—Capital £60,000 in 59,000 preferred ordinary shares of £1 and 20,000 vendor's of 1s., to adopt an agreement with (1) F. G. Small and (2) C. A. Bowen. Directors: C. A. Bowen (director Pickett Metal Corporation) and F. G. Small. Secretary: M. F. Blandford.

**John & Edwin Wright, Limited.**—Balance of revenue account, after adding amount brought forward and deducting interim dividends paid, £12,437; dividend on preference shares for half-year ended September 30 last, 5 per cent. per annum, less tax; final dividend, 5 per cent. on ordinary, free of tax, making 7½ per cent. for year, free of tax; carry forward, £6,469.

**Nantyglo & Blaina Ironworks Company, Limited.**—Amount received from royalties and wayleaves, £27,964; rent of land and houses and other sources of income, £8,215; two instalments on account of arrears of dividends upon 8 per cent. preference shares paid, £25,000, namely, on April 14 £2 per share, and on November 14 £3, making together £5 per share.

**Bolckow, Vaughan & Company, Limited.**—Loss, £269,233 for year; brought forward, £14,534, plus £500,000 transferred from general reserve, £500,000; disposable balance, after deducting loss on year's working, £230,766; debenture interest, £101,197; preference share dividend, £23,604; interest and preliminary expenses in connection with purchase of Redpath, Brown & Company, Limited, £95,683; carry forward, £24,810.

**Richard Thomas & Company, Limited.**—Profits, £481,405; depreciation and special expenditure reserve, £85,103; interest on debentures, employés' profit-sharing deposits and staff pension fund, etc., £85,083; brought forward, £163,680; dividend on preference shares for six months ended March 31 last, including tax, £116,206; provision for dividend on preference shares for six months, ended September 30 last, including tax, £112,457; ordinary dividend, 9d. per share, less tax; carried forward, £163,953.

**Dorman, Long & Company, Limited.**—Profit for year, including profit made by absorbed companies from October 1, 1922 (Bell Bros., Limited, being from January 1, 1923), to May 2, 1923, £275,454; brought forward, £201,172; total, £476,626; interest on debenture stock and debentures for year to September 30, 1923: 4 per cent. 1st debenture stock, £16,000; 5 per cent. sinking fund debentures (paid off in 1923), £13,790; 5½ per cent. redeemable debenture stock, £58,398; dividend on 6 per cent. cumulative preference shares of Bell Bros., Limited, for two months to June 30, 1923, £5,000; dividend on 6 per cent. cumulative preference shares of Dorman, Long & Company, Limited, for three months to September 30, 1923, £7,770; dividend on 8 per cent. preferred ordinary shares—half-year to March 31, 1923, paid June 30, 1923, £80,000; half-year to September 30, 1923, payable December 31, 1923, £60,000; reserve account, £50,000; balance carried forward, £202,667.

## Rating of Machinery.

THE EMERGENCY COMMITTEE of the Manufacturers' Section of the London Chamber of Commerce have the question of the rating of machinery under consideration. The members are being invited to give their views on the present practice of rating, and as to whether it would be desirable for the Chamber to offer oral or written evidence before the Committee of Inquiry. In a memorandum issued to the members the Committee points out that since 1890 repeated attempts have been made to regulate the position, and to bring about uniformity in the administration of the law as to rating. The Poor Rate Exemption Act, 1840, practically exempted all classes of machinery from rating. Subsequent decisions in the Courts, however, have caused great uncertainty as to the actual legal position. The complexity of the problem led the Government, as far back as 1896, to appoint a Royal Commission to inquire into the subject, and that body finally reported in 1901. It recommended:—"That in estimating the rateable value of any hereditament occupied for trade, business, or manufacturing purposes there should be excluded from the assessment any increased value arising from machines, tools, or appliances which are not fixed, or are only so fixed that they can be removed from their place without necessitating removal of any part of the hereditament; but the value of any machinery, machine, or plant used in or on the hereditament for producing or transmitting first motive power or for heating and lighting the hereditament should be included." In 1902 the Scottish members in the House of Commons succeeded in getting a Bill passed for Scotland on the lines of this recommendation, so that the position in Scotland to-day is clearly defined, which is that machinery is only rated where it is fixed and passes with the hereditament. As a result of the inaction of successive Governments, English manufacturers have been placed at a disadvantage compared with their Scottish and Irish competitors; considerable expenditure has been incurred in fighting unreasonable assessments and in promoting private members' bills for the removal of the anomaly; enterprise has been restricted on account of the uncertainty as to whether machinery would or would not be rated, and, if rated, to what extent; and individual manufacturers have been penalised, whilst others, sometimes carrying on business in the same or adjacent districts, have been less harshly assessed, owing to the caprice of the respective local assessment Committees. Manufacturers therefore ask that this confusion shall be removed and that the following principle with regard to the rating of hereditaments containing machinery shall be laid down:—In estimating the rateable value, for the purposes of the local rates, of any hereditament used for trade, business, or manufacture, only such machinery as may be fixed or attached to the hereditament shall be included in the assessment or taken into account, and that machines, tools or appliances which can be removed without necessitating the removal of any part of the hereditament shall not be included, or taken into account.

## Plaster Matches.

A meeting of the Burnley Section of the Institute of British Foundrymen was held on December 4 at the Municipal College, Burnley, and a Paper upon "Plaster Matches" was given by Mr. Allan Hill, of Heywood. In substance it was a *résumé* of a Paper previously given by Mr. Hill before the members of the Lancashire Branch at Manchester, which was reported in THE FOUNDRY TRADE JOURNAL. Mr. Hill exhibited a large number of diagrams illustrating various pieces of work which he explained.